USAID | PREDICT
FROM THE AMERICAN PEOPLE

2018 ANNUAL REPORT

PREDICT 2018 ANNUAL REPORT

This publication was prepared by the PREDICT Consortium headquartered at the One Health Institute (OHI), School of Veterinary Medicine, University of California, Davis.

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Suggested citation:
PREDICT Consortium. 2018 Annual Report. One Health Institute, University of California, Davis, December 2018.

Special thanks to the governments of and partners in Bangladesh, Cambodia, Cameroon, China, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Ghana, Guinea, India, Indonesia, Jordan, Kenya, Laos, Liberia, Malaysia, Mongolia, Myanmar, Nepal, Republic of Congo, Rwanda, Senegal, Sierra Leone, Tanzania, Thailand, Uganda, and Vietnam. The success realized by the PREDICT project, documented herein, would not have been possible without the valuable contributions of Andrew Clements, Alisa Pereira, Cara Chrisman, and Amalhin Shek.

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ON THE COVER
Photo Credit: Simon Townsley/The Telegraph
PREDICT/Sierra Leone's Ebola Host Project field team untangles a bat from a mist net for sampling. This year, PREDICT discovered a new Ebolavirus in free-tailed bats in Sierra Leone, see our Success Stories for more information. Photo: Simon Townsley.

I. PREFACE

Introduction

This year marked the 100-year anniversary of the most devastating infectious disease event in recorded human history, the 1918 influenza pandemic, which decimated our population and continues to serve as a reminder of just how vulnerable we are as a species. As a result of the more than 50 million deaths and associated fear, panic, and loss, the 1918 pandemic caused widespread economic, social, and political harm and further disrupted our world as we waged the First World War. It is estimated to have infected up to one third of our planet's human population, similar to infection rates seen with the 2009 H1N1 influenza pandemic that began just as the PREDICT Project was being initiated.

While pandemic prevention has advanced in the past 100 years, through innovations in science and technology that have improved our understanding of recognized infectious diseases and strengthened our ability to detect, treat, and prevent them, our preparedness for the threat of new or unexpected diseases has not advanced comparably. Through global engagement, we have worked to improve our planet's health security through strategic investments in health systems and international cooperation. Yet the pandemic threat remains.

This year did not bring a resurgence of the influenza strain that caused the 1918 pandemic, yet as we prepared to welcome 2019, health care workers in eastern Democratic Republic of Congo rushed to combat their second Ebola virus outbreak in just a year, now the second largest ebolavirus outbreak since the 2014 outbreak in West Africa that caused massive global disruption and over 11,000 deaths. We are seeing an increase in the emergence and spread of infectious diseases as well as the conditions that may promote them: instability and conflict, changes in land use, natural disasters exacerbated by climate change, migrating human populations across borders and increasingly from the countryside to cities, and health systems struggling to cope with the burden of disease and dynamic challenges.

2018 was our fourth year implementing the second phase of the US Agency for International Development's (USAID) PREDICT project (www.predict.global), an innovative pillar of USAID's Emerging Pandemic Threat's Program designed to tackle these challenges head-on in some of the world's most vulnerable hotspots for disease emergence. PREDICT, which launched in 2009, is charged with building a consortium of global partners to strengthen capacity for surveillance and detection of viral threats to preemptively confront them before they become pandemics. Throughout the year, our teams, using the One Health approach in 28 low and middle income countries in Africa and Asia, made significant strides towards that end and towards strengthening global health security.

This year our project reached maturity, providing proof of concept for early detection of potentially deadly diseases through the discovery of a new ebolavirus in bats in Sierra Leone and by working closely with our Government of Sierra Leone partners to design and implement a prevention and risk communication campaign in communities in Sierra Leone and across Africa where these bats reside.

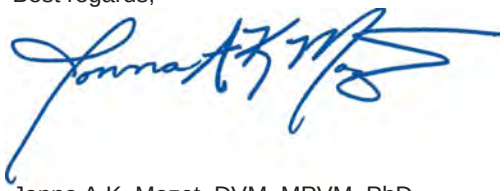
We continued to support development of the world's One Health workforce, supporting professional development and training for over 600 staff and team members from our host country partners, who this year achieved a major project milestone by completing One Health surveillance through sampling wildlife and domestic animal populations and at-risk human communities where viral spillover and spread are most likely to occur. To date, our capacity strengthening team has worked to serve over 550 health professionals, including 104 members of tomorrow's workforce, and over 300 faculty members at host country universities or research institutes, Further, we continued to support disease detection in more than 60 labs and to promote One Health laboratory networks in Africa and Asia. Forty labs now have the capability to test for known and emerging viral threats, which combined with our investments in human resources will be a lasting contribution to education, science, and health security.

Also this year, our PREDICT teams supported 10 outbreak response investigations in five countries, helping partners get to the source of diseases of unknown origin and preemptively head off potential outbreaks in animal populations before they infect people. In Thailand, our PREDICT lab at Chulalongkorn University was requested by government partners to use our disease detection platform, optimized to screen for known and unknown viruses of bat origin, to support health evaluations for members of the Thai soccer team trapped in a cave, a widely publicized international emergency.

We also continued to invest in the science and knowledge of emerging infectious diseases, developing risk maps and models to inform policy and guide surveillance and detection efforts, and producing 39 publications (many in top tier journals such as Nature) and 40 evidence-based resources and policy briefs.

In this year's 2018 Annual Report, we are proud to showcase these successes and other achievements, which reflect the hard work, talent, and dedication of a truly amazing and unique global team. In 2019, our One Health team will continue to advance the frontiers of knowledge of emerging diseases and work to create long-lasting and self-reliant platforms for disease surveillance, detection, and control.

Best regards,



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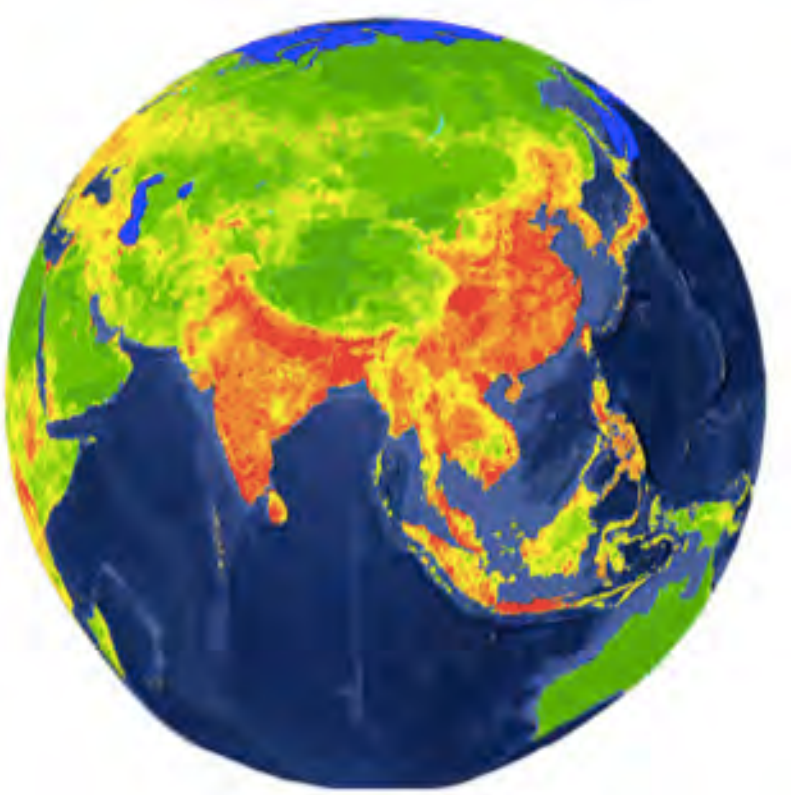
USAID | PREDICT

FROM THE AMERICAN PEOPLE



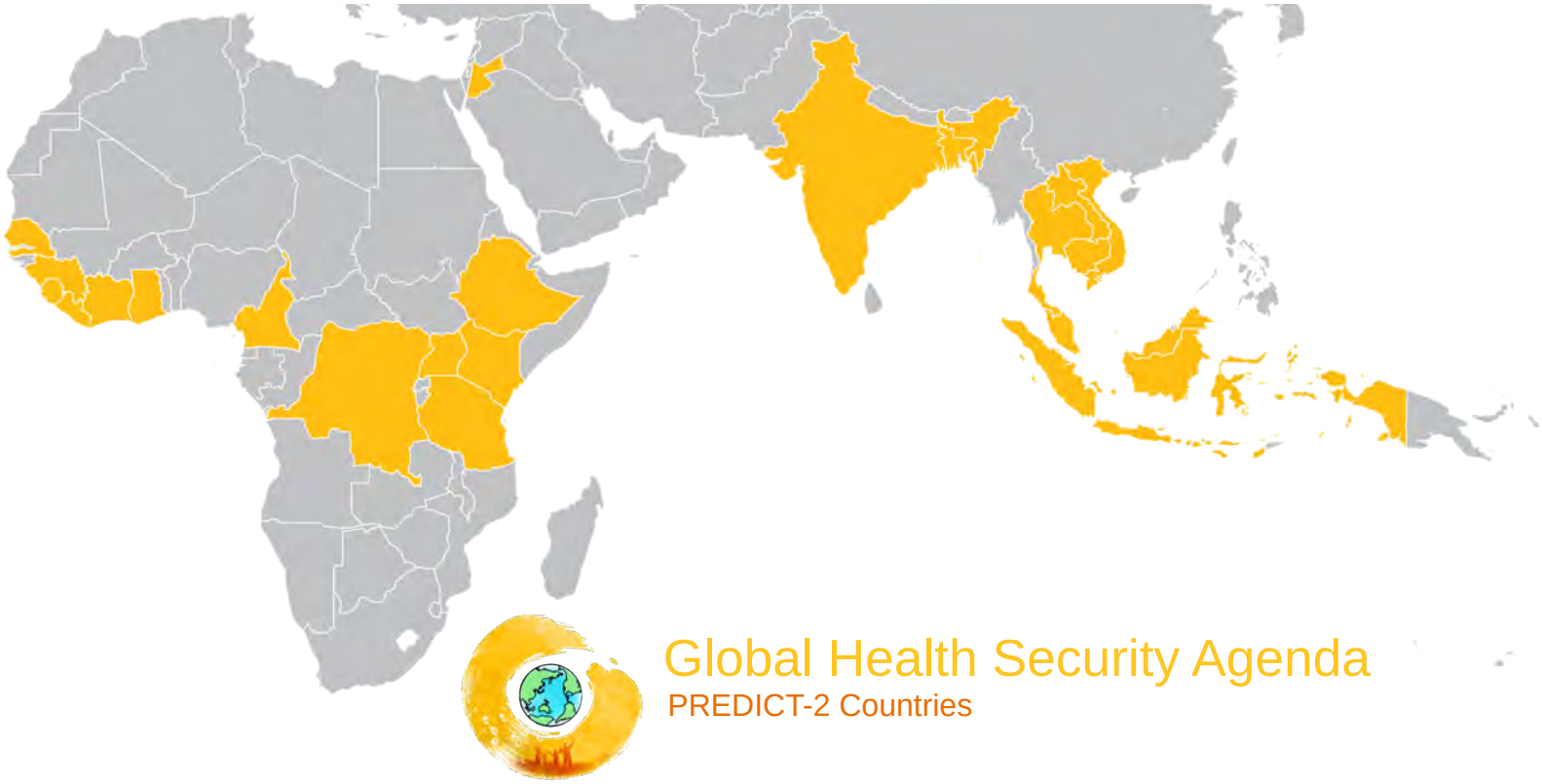
PREDICT, a project of USAID's Emerging Pandemic Threats (EPT) program, was initiated in 2009 to strengthen global capacity for detection and discovery of viruses with pandemic potential that can move between animals and people. Those include filoviruses, such as the ebolavirus and Marburg virus; influenza viruses; coronaviruses, the family to which SARS and MERS belong; and paramyxoviruses, like Nipah virus.

PREDICT has made significant contributions to strengthening global health security by improving surveillance and laboratory diagnostic capabilities for new and known viruses.

Now working with partners in 30 countries, PREDICT is continuing to build platforms for priority viral surveillance and for identifying and monitoring zoonotic pathogens or those that can be shared between animals and people. Using the One Health approach, the project is investigating the behaviors, practices, and ecological and biological factors driving disease emergence, transmission, and spread. Through these efforts, PREDICT is improving global disease recognition and beginning to develop strategies and policy recommendations to minimize pandemic risk.

REDUCING PANDEMIC RISK, PROMOTING GLOBAL HEALTH

Supporting the Global Health Security Agenda in Africa & Asia



PREDICT is actively and diligently implementing GHSA activities in target countries aimed at developing and operationalizing strategies to improve disease management efficiencies in the short term and reduce zoonotic pathogen spillover, amplification, and spread in the long term, through improved public health policies and risk reducing mitigation efforts. In every country of engagement, we work hand-in-hand with governmental and non-governmental stakeholders to develop and implement activities that are tailored to country and regional priorities and specifically designed to strengthen capabilities and ensure lasting positive effects from our engagements.

Using the One Health approach to improve capacity for **zoonotic disease** management and **surveillance** in a cross-sectoral manner and enable early detection of known and emerging disease threats, PREDICT is making significant contributions to strengthen **biosafety and biosecurity**, **national laboratory systems**, and **reporting** efficacy in all engagement-countries, while also improving the stability of these systems through One Health **workforce development**.

The PREDICT Consortium & Management

The USAID/PREDICT Consortium is a functionally collaborative working team that implements the project through in-country partners and benefits from the experience of world leaders in zoonotic disease detection and surveillance, epidemiology, disease ecology, and risk characterization. PREDICT's consortium includes partnerships with ministries of health, agriculture, and environment and implementing university and NGO partners in 30 countries.

USAID/PREDICT global-level consortium institutions

- **UC Davis' One Health Institute**, based in the most highly-rated veterinary school in the world, is active all over the globe, working at the interface of animals, people, and the environment to solve complex problems that impact health and conservation.
- **EcoHealth Alliance** is the first group to identify bats as the reservoir of SARS-like coronaviruses, to define hotspots of emerging diseases, and identify drivers of disease emergence.
- **Metabiota, Inc.** has made seminal discoveries regarding the role of hunting of nonhuman primates and food handling in moving animal pathogens to humans.
- **Smithsonian Institution and the National Zoo** are among the founders of the field of conservation biology.
- **Wildlife Conservation Society** was the first conservation organization with a dedicated team of wildlife veterinarians deployed around the world, with programs focused on environmental stewardship and health problem-solving.
- Other global partners include **Columbia University**; **Boston's Children (HealthMap)**; and the **International Society for Infectious Disease**.

Contact

Follow us on social media: ResearchGate for scientific publications and presentations and Twitter **@PREDICTproject**) for general outreach and information.

www.predict.global | predict@ucdavis.edu

Photo: PREDICT/DR Congo

II. SUCCESS STORIES

SUCCESS STORIES

EBOLA HOST PROJECT

SIERRA LEONE: Discovery of the Bombali virus in bats

The devastation left by an unprecedented Ebola virus outbreak between 2013 and 2016 revealed an urgent need for viral detection, capacity strengthening, and effective risk messaging at all levels. The PREDICT/Sierra Leone team has worked diligently to strengthen viral detection capacity and perform surveillance activities in more than 5 districts throughout the country. For the first time, scientists discovered a new ebolavirus species in a host prior to detection in an infected human or sick animal. The discovery of the Bombali virus in free-tailed bats in Sierra Leone has provided the strongest evidence to date that bats are most likely the natural hosts of these viruses. Published in August 2018 in Nature Microbiology, the discovery of the Bombali virus and the sequencing of the complete genome were shared with people around the world. The government of Sierra Leone announced this finding in July 2018 at the national level, followed by district and community-level dissemination meetings. The discovery,

PHOTOS (left-right): PREDICT/Sierra Leone team leading community briefings alongside local chiefs on the discovery of the Bombali virus; behavior risk team engages with Kakamba village community to educate members on zoonotic disease transmission risks; opening ceremony of the PREDICT Findings Briefing.

a part of the Ebola Host Project, was highlighted by a UK-based Telegraph newspaper team, who expressed interest in following local capacity strengthening and virus research work. Despite more than 40 years of research, the true reservoir hosts for this group of viruses is still unknown. But, the discovery of Bombali virus adds to growing evidence that bats are the likely hosts of these viruses.

This discovery demonstrated the strength of the mission of USAID's PREDICT project, which aims to find viruses before they spillover into humans while building local and regional capacity for detection and surveillance. In October 2017, PREDICT/Sierra Leone hosted a 10-day multi-national continuing education training, training more than 20 transdisciplinary staff from Senegal and Guinea at the University of Makeni Sierra Leone on safe capture, sample, and transport of biological specimens from remote locations to diagnostic laboratories. Over the duration of the project, PREDICT Sierra Leone has sampled over 6,500 animals including bats, rodents, livestock, dogs, cats, and non-human primates and collected over 19,000 specimens for testing. Community engagement is an influential aspect of the PREDICT project, in which the Sierra Leone team has engaged over 400 stakeholders at district, chiefdom, and community levels in our operational districts (Kambia, Bombali, Kono, Koinadugu, Western Area rural and Pujehun).

EBOLA HOST PROJECT

PHOTO: Alpha Camara, Country Coordinator of PREDICT/Guinea demonstrating the importance of the "Living Safely with Bats" book during a meeting with Guinean Ministry of Health representatives.

GUINEA: Preemptive communication of Ebola risks in Guinea

In July 2018, PREDICT/Guinea met with the Guinean government (Ministry of Health, Higher Education, Environment, Livestock and the Agence Nationale de Securité Sanitaire (ANSSE)) to introduce the Sierra Leone finding and its viral characteristics, and to discuss potential risks to humans and wildlife. The team addressed questions about BOMV, gave recommendations, and shared plans for risk communication with local communities. Throughout the Ebola Host Project (EHP) in Guinea, One Health partnerships and relationship building with government and local communities have been emphasized at every step beginning with the initiation of animal sampling. These public engagement meetings, advocacy, and trainings are a critical part of EHP activities, and this foundation proved to be important when faced with communicating the first real test findings and potential risks to different sectors and across national and community level stakeholders. Community engagement efforts will continue, as our team works to inform local populations about the finding as well as ways to reduce the risk of exposure to the virus. Both the Guinean government representatives and PREDICT team agreed on the importance of raising awareness of potential zoonotic disease threats among communities at risk and on working together to strengthen the animal health sector's capacity to detect priority zoonotic diseases, such as Ebola, a key area of emphasis for the country's JEE. Putting these plans into action, PREDICT/Guinea translated materials into French and began presenting the Living Safely with Bats book to local villages and at-risk communities. This book is a pictorial risk communication tool developed by PREDICT for use in community engagement activities and contains a collection of prevention measures designed to provide guidance on how to live safely with bats and avoid exposure to potential zoonotic threats such as BOMV and other ebolaviruses.

EBOLA HOST PROJECT

PHOTO: Members of PREDICT/Liberia's human surveillance and animal teams simulate presenting *Living Safely with Bats* to community audiences.

LIBERIA: Preparing to engage with communities for risk reduction & behavior change communications

A behavioral risk workshop took place shortly after PREDICT's announcement of the Bombali virus discovery in Sierra Leone. To prepare for outreach and communications with national and community level stakeholders about this important finding (the first detection of a new ebolavirus in a bat), PREDICT's behavioral risk leads trained Liberia team members from both the human and animal health research teams on effective community education and presentation strategies using the project's Living Safely with Bats resource, an educational picture book developed by PREDICT for use in populations living in or near areas that could bring them in contact with bats. This training prepared the team to anticipate and respond to questions, dispel rumors, and engage with local communities in understanding safer ways to live near bats, a critical need given the potential sensitivity around the new finding that bats in neighboring Sierra Leone are a host species for the Bombali virus.

SUCCESS STORIES

LIVING SAFELY WITH BATS

West Africa Communication Campaign

PHOTOS (above): PREDICT teams presenting Living Safely with Bats to community members.

PREDICT teams working with the Ebola Host Project in West Africa identified a need to provide behavior change strategies as they relate to Ebola and living safely with bats following the discovery of a new ebolavirus in bats in Sierra Leone. In response, PREDICT worked closely with USAID and local partners to swiftly develop a communications plan and a behavior change intervention resource to help raise awareness among community members about ways to reduce disease risks associated with human-to-bat contact.

To identify the most culturally appropriate, feasible, and effective intervention resource format, PREDICT developed a framework for assessing potential materials, channels of communication, respective audiences, and core messaging. A moderated picture book format, delivered by a trusted community leader, was selected as the best tool to put into the hands of our local team and in-country stakeholders. A communications plan was developed to ensure a well-coordinated effort and timely discussions with government and community stakeholders, following the release of the new ebolavirus finding.

This new resource, *Living Safely with Bats* leveraged the subject matter expertise of PREDICT's interdisciplinary One Health team who contributed technical content. All illustrations were developed by a team member trained in animal biology and visual arts to ensure accurate, consistent, and compelling visual representations throughout the book.

Living Safely with Bats

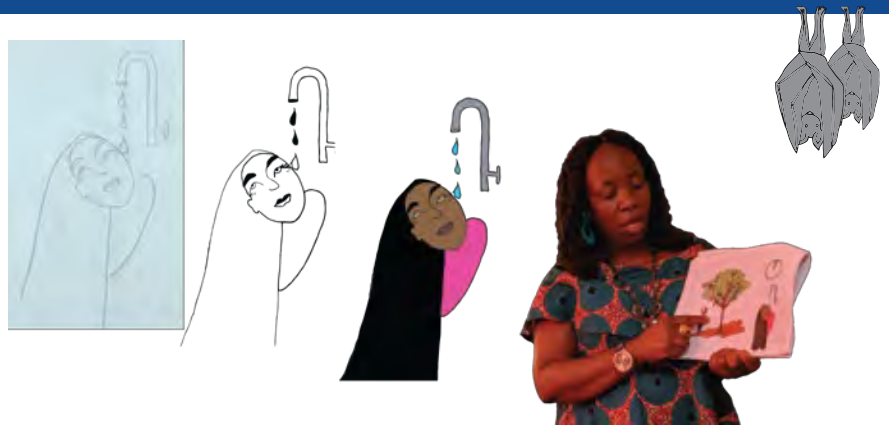


Figure 8: Evolution of the Living Safely with Bats risk reduction picture book.

This new resource, *Living Safely with Bats* leveraged the subject matter expertise of PREDICT's interdisciplinary One Health team who contributed technical content. All illustrations were developed by a team member trained in animal biology and visual arts to ensure accurate, consistent, and compelling visual representations throughout the book.

Figure 9: Illustrations with moderator talking points.

Focus groups were also held with PREDICT's subject matter experts to refine the picture book, and feedback was solicited from project country teams. The book's content benefited from cultural vetting by 17 country teams (Bangladesh, Cambodia, Cameroon, Cote d'Ivoire, DRC, Ghana, Guinea, Indonesia, Lao PDR, Malaysia, Nepal, ROC, Senegal, Sierra Leone, Tanzania, Thailand, and Vietnam).

The *Living Safely with Bats* resource was piloted in Sierra Leone and Tanzania (in collaboration with a US Department of Defense, Defense Threat Reduction Agency project also working at the bat-human interface) to garner input on ways to improve both the content and the process of delivery. A comprehensive review of the book was also conducted in Guinea. Representatives from PREDICT's Behavioral Risk team were present in West Africa to train and support country partners during the launch of this resource, and the picture book was successfully delivered to community partners during community outreach events in Sierra Leone, Guinea, and Liberia starting in July and August 2018 (Figure 10).

Figure 10: PREDICT collaborated with local partners to raise community awareness on ways to reduce disease risks ssociated with humanto-bat contact.

This resource was also made public on the PREDICT website **(www.predict.global)**. To date, it has been accessed 100 times by community leaders, community members, and students, as well as individuals who work in numerous fields and institutions, including: academia, research, public health, animal health, NGOs, elementary schools, US government agencies, development, communications, museum libraries, and bat conservation.

Revisions are underway to adapt the book to Asian contexts, and modules are being developed on bat hunting, guano harvesting, and cave-related tourism.

SUCCESS STORIES

PHOTO: PHOTO: Veasna Duong advising PREDICT/ Cambodia lab team members at Institute Pasteur Cambodia.

Preventing a Pandemic in

CAMBODIA

In 2017, an endangered Hairy-nosed otter was found suddenly dead at the Phnom Thmao Zoo, outside of Phnom Penh. The otters at Phnom Thmao, a zoo run by the Forestry Administration (FA) under the Ministry of Agriculture and Forestry, were rescued from illegal wildlife trade and are part of a conservation breeding program. They also are in close contact with the many daily visitors to the zoo.

A necropsy on the otter was performed, which revealed blood clots in the brain, abnormal kidneys, congested lungs and an abnormal heart. Phnom Tamao Zoo initially consulted with the Wildlife Conservation Society, a PREDICT partner, who recommended sending samples for testing to the Institut Pasteur Cambodia laboratory, the National Influenza Reference Laboratory for Cambodia and PREDICT's partner lab. The IPC lab has adopted PREDICT's viral detection protocols, which screen for both known and emerging viral threats, and has been using them to test wildlife samples in the case of undiagnosed die-offs, such as with the Phnom Tamao otter. IPC technicians tested the animals' samples with these protocols and detected the presence of Influenza A. Subtyping results indicated that highly pathogenic H5N1 Avian influenza was the cause of this poor otter's death.

PHOTOS (above): PREDICT/Cambodia lab work at Institut Pasteur Cambodia.

The team immediately reported the finding to the animal health authorities, which led to an epidemiological investigation by the government's influenza team. The influenza team's disease detectives traced the source of infection to raw poultry from a local market, meat that had been fed to the otter. Following identification of H5N1 in this case, surveillance and control measures at the local market were initiated and practices were put in place to protect the human and animal populations and their food chain.

PREDICT has been working around the world to prevent pandemics by strengthening One Health surveillance and disease detection systems. In Cambodia, the adoption of our viral detection protocols for wider use in national influenza surveillance along with the presence of an informed multi-sectoral One Health network led to the successful detection of Influenza A in the food chain. The rapid response to the infection and death of an unusual wildlife species enabled the management and control of a potentially deadly outbreak of a known pandemic threat.

"PREDICT viral family/genera testing protocols are a great asset for our laboratory for screening emerging pathogens of known or unknown origin and have allowed us to investigate viral aetiology in several outbreak events from wildlife such as the detection of H5N1 Avian influenza in an unusual host, an otter." -Veasna Duong, PREDICT/Cambodia

SUCCESS STORIES

PHOTO: PREDICT/Mongolia avian influenza surveillance team inspecting a common shelduck as part of the outbreak response.

MONGOLIA

Rapid Response to a Wild Bird Die-off

On August 11, 2018, local veterinarians notified the provincial veterinary office of a large die-off of wild birds at Sangiin Dalai Lake (N47.40, E94.96) in Western Mongolia. On August 24, the PREDICT/Mongolia team in Ulaanbaatar was alerted to the event by local government veterinarian contacts, and the State Central Veterinary Laboratory (SCVL) shared initial in-house test results that were negative for avian influenza

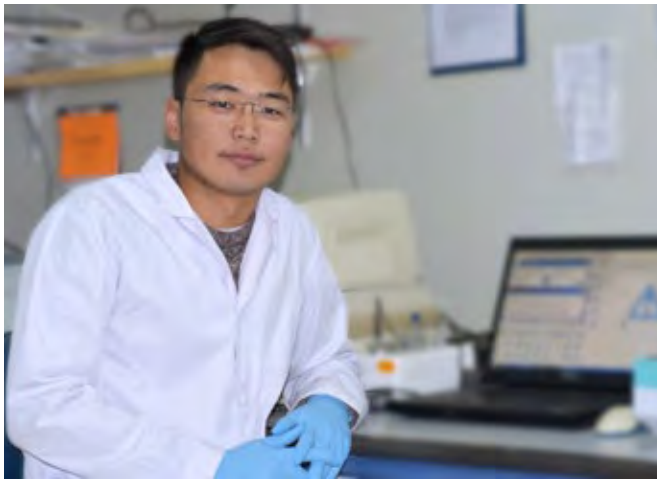
and Newcastle disease virus. On the same day, the PREDICT/Mongolia avian influenza surveillance team was redirected to the die-off site to assess the situation and collect samples, as they were already en route to the region to conduct field work.

Sangiin Dalai Lake is a salt water lake located at front edge of the Mongol Els Protected Area in Khokhmorit Soum, Gobi-Altai Province. The lake is surrounded by sand dunes and small sandy hills.

Once in the area, the PREDICT team worked closely and successfully with SCVL staff, local veterinarians, environmental inspectors of the district, and Mongol Els Protected Area rangers to implement response activities. For several days in late August, they observed and identified the bird species, conducted a shoreline transect to detect and count sick and dead birds, necropsied and sampled dead birds, collected guano samples,and met with herders in the vicinity of the lake. Clinical signs exhibited by the sick birds included extreme weakness, inability to fly or swim, wing droop, and bent necks (torticollis). During the survey, the team identified 12,648 individuals of 49 species. Common shelducks represented 70% of the 254 dead birds, with smaller numbers of gulls and avocets, mallards, and teals. Combined with earlier government surveys a total of 3,216 bird deaths were recorded.

PREDICT collected a total of 85 samples at Sangiin Dalai Lake, including 25 tissue samples, five oral swabs, and five cloacal swabs from dead birds, and 50 guano samples from graylag goose. To assist with interpretation of observations, gross pathology findings and video of birds that exhibited clinical signs of disease were relayed via satellite phone and email to global PREDICT staff.

By August 30, the collected samples were undergoing testing at SCVL, the PREDICT partner laboratory in Mongolia. Additional testing, incorporating PREDICT protocols for avian influenza and paramyxoviruses were negative. Histopathology and bacteriology testing did not identify a pathogen. Additional laboratory testing is ongoing for avian botulisum (*Clostridium botulinum*) and other toxin-related causes initial in-house test results that were negative for avian influeconsistent with field findings, but the cause of the die-off remains unknown. The PREDICT team used the die-off as an opportunity to share information and recommendations of avian influenza and other potential diseases with local government staff and herders.



PHOTOS (clockwise from top-left): Ariunbaatar Barkhasbaatar with camera equipment; Ariunbaatar in the field; Batchuluun Damdinjav performing a necropsy at Sangiin dalai lake; Ulaankhuu Ankhanbaatar in the lab; Ulaankhuu loading tubes.

SUCCESS STORIES

THAILAND

Investigating viral threats after the Tham Luang Cave Rescue in Thailand

On June 23, 2018, twelve boys from Wild Boars soccer team and their coach set out on an adventure to explore the vast Tham Luang Nang Non cave complex (“The Great Cave of the Sleeping Lady”), near the village of Pong Pa in northern Thailand. But due to the rapid onset of monsoon rains, caverns in the cave began to flood and the Wild Boars were trapped deep in submerged caverns, separated from the entrance by miles of flooded chambers.

The boys were trapped and missing for nine days before specialist rescue divers located all 13 of the Wild Boars team members. Then another nine days passed before all 12 boys and their coach were rescued from the cave by the divers in a massive operation that involved more than 10,000 people, miles of hose and rope, pumps, generators, and countless supporters .

The collaborative rescue was a multi-national and interdisciplinary success, and even featured One Health expertise, as the PREDICT/Thailand partner laboratory at Chulalongkorn University was requested by the Thai government and the Ministry of Public Health (MOPH) to provide technical assistance with health evaluations following the team’s rescue. As part of these efforts, PREDICT’s lab team tested specimens from all 13 individuals in July 2018

PHOTO: Tham Luang Nang Non cave complex.

PHOTOS (clockwise from top): a group photo of the team; the lab team prepares to test the samples; PREDICT/Thailand's country coordinator receives the samples. (Credit: PREDICT/Thailand)

Being trapped in a cave, without any access to food or proper source of water can compromise the immune system and increased an individual's susceptibility to infections. Caves are known to present health risks, as inhabitants often include bats, rodents, insects,or parasites that harbor a wide variety of infectious bacterial, fungal or viral pathogens, potentially even the next major pandemic threat or "Disease X".

Following the rescue, as the team were carefully monitored by health experts, PREDICT's lab team based in Bangkok, provided MOPH staff advice on safe collection of specimens for viral screening, and then prepared to test the specimens for infectious pathogens. PREDICT's sampling protocols were used to collect specimens and our project's viral detection protocols, which can identify both known and emerging disease threats were used for screening. In addition to testing at our PREDICT lab, specimens were also shared with One Health network laboratories, including DMSc, Thai AFRIMS, US AFRIMS, Department of Microbiology and Parasitology, Faculty of Medicine, Chulalongkorn University. Lab teams simultaneously ran specific assays for targeted diseases along with PREDICT family-wide viral detection assays to ensure results within 24 hours.

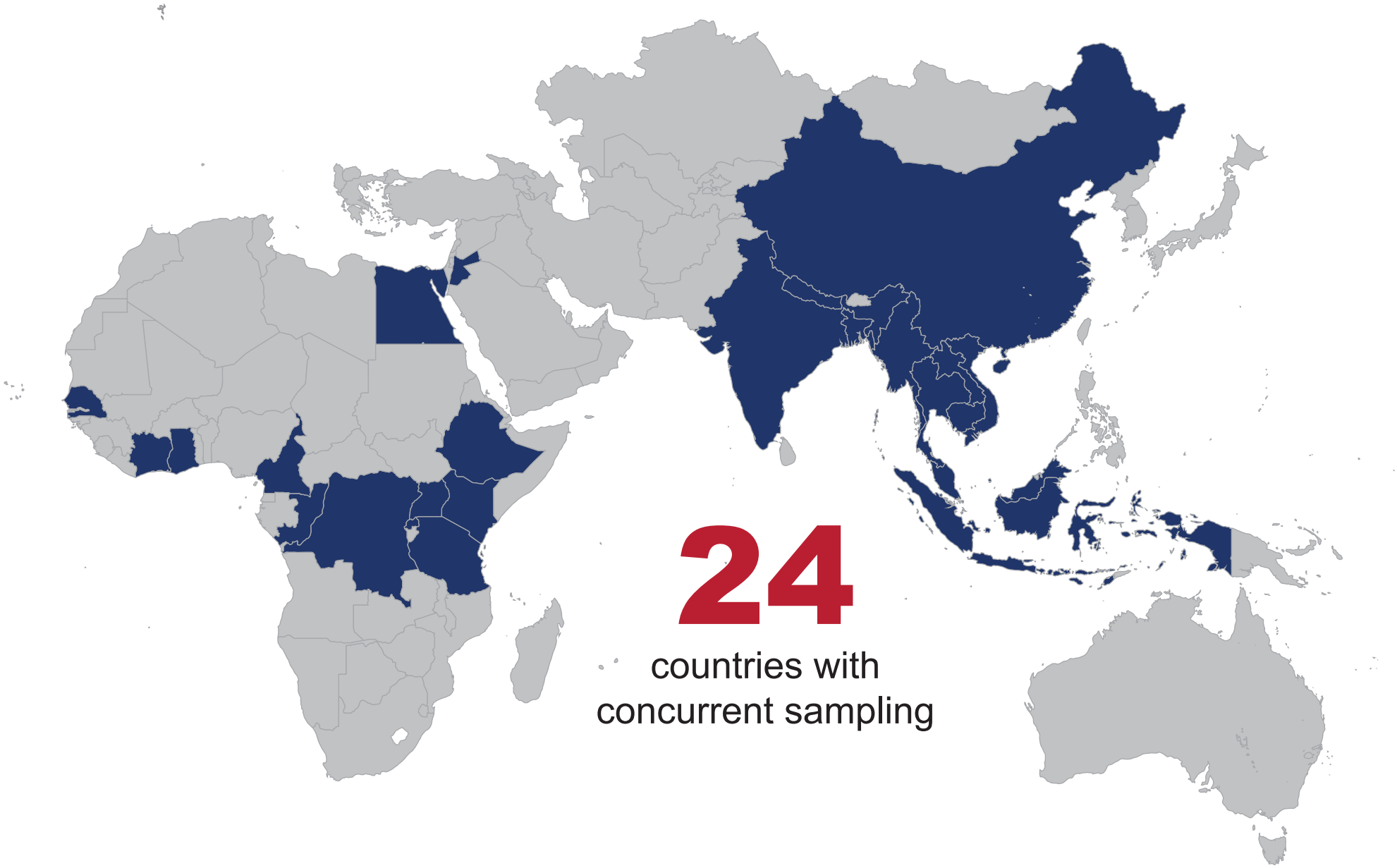
"Fortunately, none of the rescued team members tested positive for any pathogens related to cave and resident wildlife hosts."

The health evaluations following the cave rescue demonstrate Thailand's proactive approach to One Health surveillance and response. In addition, the strengths of the national laboratory system were prominent, as Thailand's disease detection network successfully collaborated to sharedata and information for rapid detection and identification of disease threats.

Photo: PREDICT/Guinea

III. MONITORING & EVALUATION

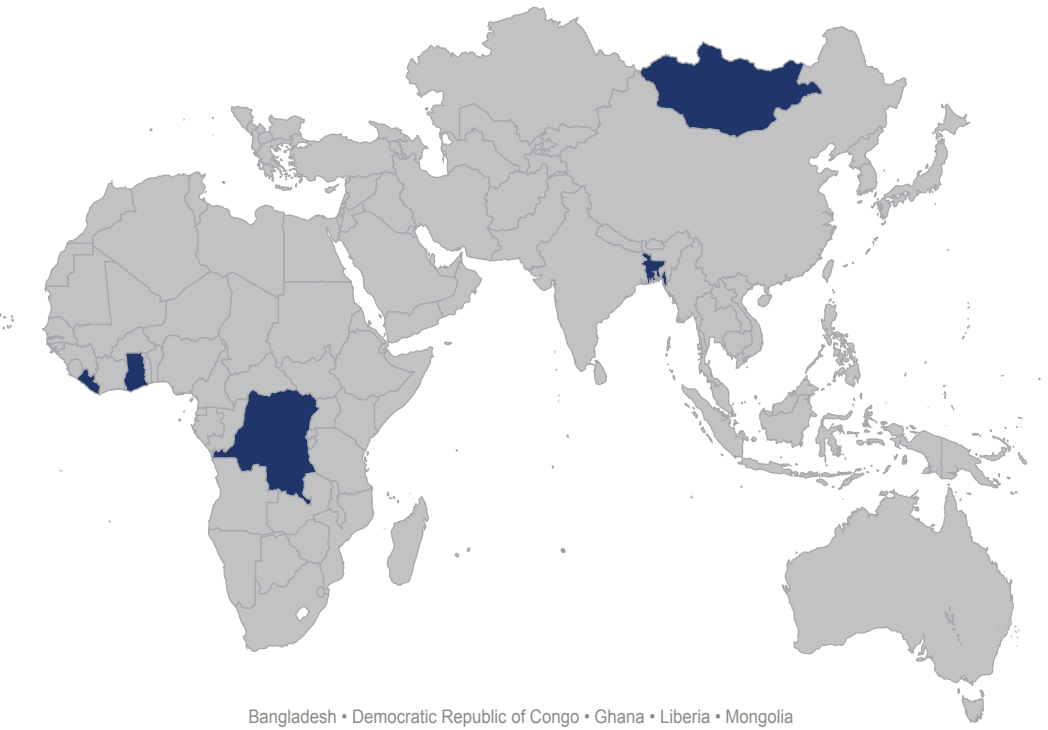
CONCURRENT SAMPLING
2017-2018



Concurrent Sampling

Sampling of humans and animals at a similar time and place, 100% of target achieved.

OUTBREAK RESPONSE ASSISTANCE 2017-2018



Bangladesh • Democratic Republic of Congo • Ghana • Liberia • Mongolia

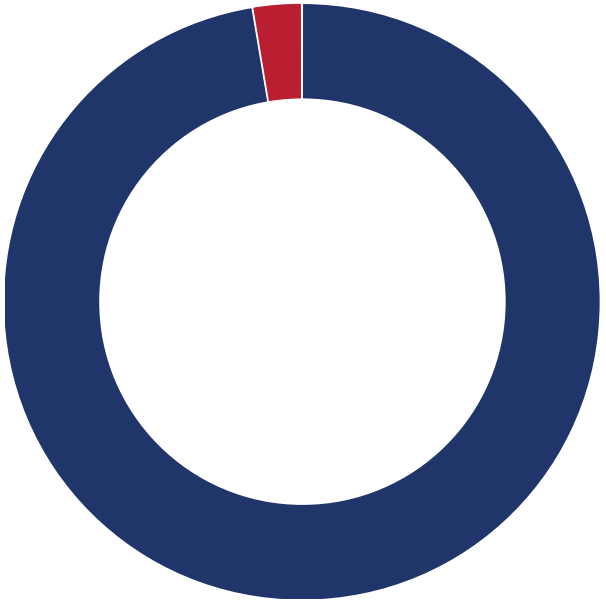
10

Outbreak events

5

Countries

STAFF IN COUNTRY 2017-2018



Staff from host country

Staff from outside of host country

271

Total Staff

97%

From host country

1

Staff from region

264

Staff from host country

6

Staff not from country or region

ONE HEALTH TOOLS & RESOURCES 2017-2018

24
Educational materials developed

45
Evidence-based informational resources

39
Publications

3
Policy briefs

ONE HEALTH STRENGTHENING 2017-2018

23
Countries with global, regional or country level strategies under implementation

23
Countries that show evidence of One health trainings and sensitization in the workforce

17
Countries coordinating community One Health events

RISK FACTORS & RISK INTERFACES 2017-2018

48

Risk factors and risk interfaces characterized since the beginning of PREDICT-2 in 2014

RISK MODELS & MAPS 2017-2018

88

Models or maps developed, refined, analyzed, and described

42

Viral

4

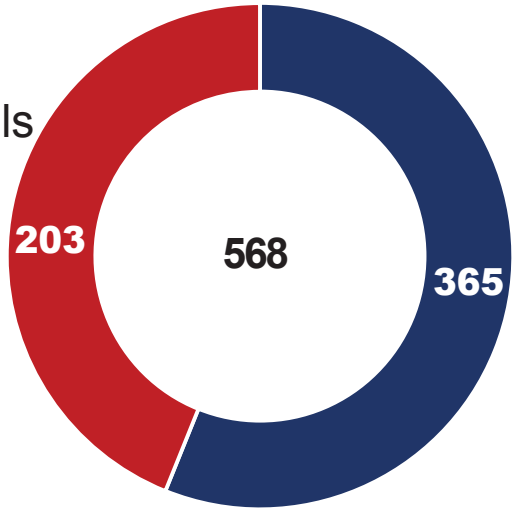
Bacterial

42

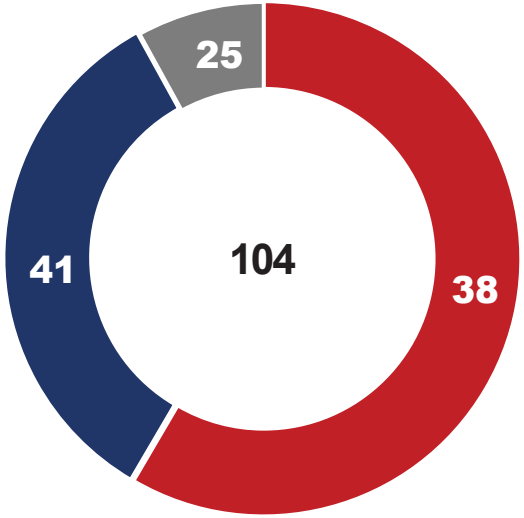
Disease risk

ONE HEALTH WORKFORCE CAPACITY 2017-2018

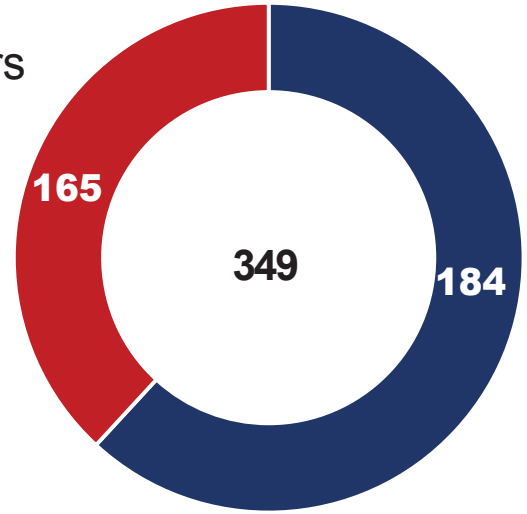
Current professionals trained



Future professionals



Faculty members who received training



One Health fellows placed

Males trained

Females trained

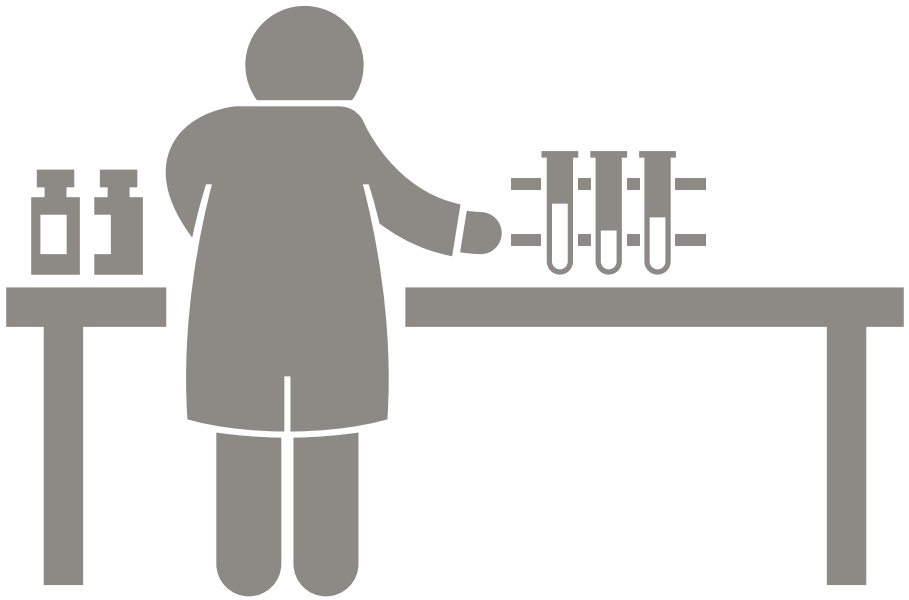
Trainees who did not declare gender

LAB STRENGTHENING
2017-2018

303,987
Tests performed

35
Labs able to perform
PREDICT prioritized testing

40
Labs improving quality assurance
and safety procedures



PREDICT ACTIVITY	DEFINITION	MONITORING INDICATOR
Strenghtening Systems for Prevention, Detection and Response		
Outbreak Response	Providing technical assistance with outbreak response if requested by the government and approved by USAID	Description of outbreaks responses supported
One Health Surveillance and Risk Characterization	Conducting animal and human sampling; Conducting biological and/or behavioral data collection; Collecting data on ecological and epidemiological factors associated with virus evolution, spillover, amplification, and/or spread; Collecting data on animal-human contact for characterization of behavioral risk; Prioritization and description of identified intervention points to inform development of risk mitigation approaches	List of countries with concurrent sampling; Characterized risk factors or interfaces associated with spillover, amplification and/or spread; Intervention points prioritized for development of risk mitigation approaches
Modeling and Analytics	Development of tools to better understand the emergence of disease pathogens	Viral, bacterial, or other disease risk pathway models or maps developed and/or refined
Lab Strenghtening: PREDICT Viral Family Screening	Laboratories have adequate infrastructure (facilities, lab equipment, staff, etc.) and sufficient training to conduct consensus PCR (cPCR) testing for the minimum four viral families (corona-, paramyxo-, influenza-, filo-) using PREDICT protocols and can perform, or have support to perform, cloning and sequeuncing to confirm PCR positives and to identify the virus present	Percentage of labs improving quality assurance and safety procedures; percentage of labs able to perform EPT2/GHSA prioritized testing and number of tests performed

PREDICT ACTIVITY	DEFINITION	MONITORING INDICATOR
Workforce Capacity		
Workforce Development: Training and Materials Developed	Personnel and/or students participating in the following types of trainings; Field Sampling, Information Management, Laboratory Techniques and Assay Development, and Risk Characterization	Number of faculty members that received OH training or professional development; Number of future professionals trained; Number of OH fellows placed; Number of current professionals trained; List of publicly available education, training, and/or implementation resources developed and shared
Workforce Development: Local Capacity	PREDICT training and employment of local or regional staff members in host countries	Evidence of application of OH trainings and sensitization in the workforce; Total number of in-country staff who are from the host country or region
One Health Strengthening		
Advancement and improvement of One Health practices and policy	Development of One Health resources (including guidelines, technical protocols, standard operating procedures, standardized data collection instruments and protocols, and instructional tools and manuals for implementing risk mitigation recommendations) to provide evidence-based guidance on the operationalization and/or implementation of One Health principles and approaches; inform policy change through evidence based solutions	Evidence-based informational resources developed including policy briefs, research papers, situational analysis/risk assessment, and zoonotic prioritization resources; List of community OH events coordinated

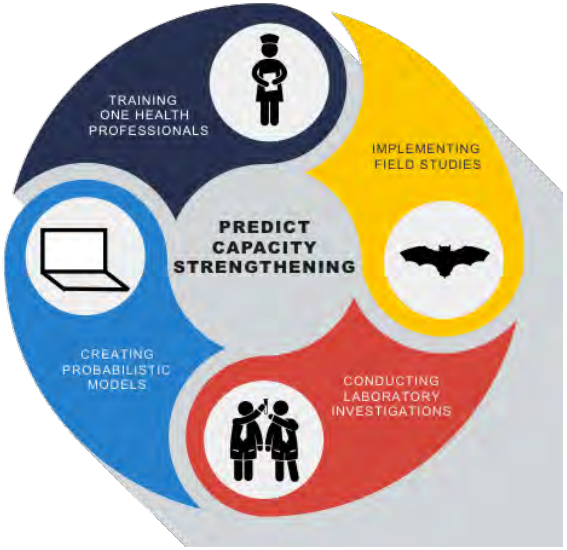
Photo: PREDICT/Thailand

IV. GLOBAL REPORT

Capacity Strengthening

Enhancing the One Health workforce for outbreak preparedness

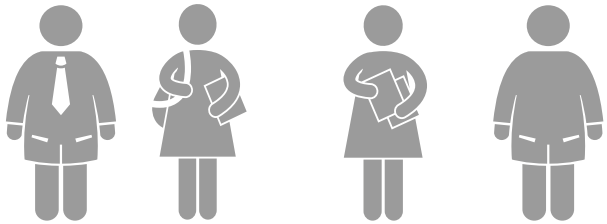
Emerging viruses have the potential to spillover and cross borders; as such, it is critical to build the international network of health professionals that can detect, respond to, and prevent these health threats. PREDICT-2 has been working in over 28 countries to foster leadership and transdisciplinary thinking in the next generation of One Health professionals through 'on the job' training that enhances global health security. Since October 2014, more than 2,700 individuals have been trained in PREDICT-2 countries where One Health surveillance activities are being implemented. Of these individuals, over 800 staff and students were trained in animal sampling, biosafety, and laboratory protocols in 2017-2018.



PREDICT-2 uses an integrated approach to train personnel on One Health competencies that enable field surveillance activities, laboratory testing for priority zoonotic diseases and other emerging threats, outbreak assistance, and informed behavior change that improves our understanding of zoonotic disease risks at key wildlife-livestock-human interfaces where spillover events may occur.

WORKFORCE DEVELOPMENT

	STAFF	STUDENT	GOVERNMENT	OTHER
YEAR 4	690	335	609	48
TOTAL	1023	548	1073	100



Since 2014, PREDICT-2 has trained over 2,700 individuals in animal sampling and laboratory testing in over 20 countries. Individuals trained include PREDICT staff, university students, government officials, and individuals associated with other organizations.

Outbreak preparedness is essential for a functional One Health workforce. Since 2014, our project has trained over 1,050 government officials (>500 host government officials in 2017-2018) in core skills that enhance outbreak preparedness and response, a major contribution to sustainability and longevity of national health systems. In addition, we continued to strengthen regional capacity by working at high risk human-animal interfaces to conduct aligned surveillance in wildlife and humans. This year, our teams continued conducting cross-boundary regional training exchanges to share knowledge and develop a community of One Health practice. For example, PREDICT/Sierra Leone hosted members of the PREDICT/Senegal and Guinea teams for an intensive training series on disease surveillance activities covering biosafety, animal sampling techniques, human syndromic surveillance, and sample storage transport and management. In Liberia, our global behavioral risk team hosted members of PREDICT/Liberia and Guinea to strengthen social science skills for community outreach and behavioral risk investigations. Expanding One Health laboratory linkages, PREDICT/Malaysia hosted team members from Indonesia and engaged in discussions on biosafety and laboratory design.

Contributing to long-term national improvements for zoonotic disease detection and response

PREDICT-2 continued to build key partnerships within and across active countries, as exemplified through collaborations with universities, ministries, and international organizations in Asia and Africa. In Cameroon for example, our team responded quickly to immediate training needs of the local workforce and contributed to ongoing efforts to improve education for future wildlife health professionals. Together with FAO, the PREDICT/Cameroon team worked to foster relationships and conducted an intensive training in wildlife disease surveillance for 24 host government staff, thereby improving technical skillsets and creating increased awareness for key government officials critical for Cameroon's national health security.

This year, many PREDICT countries contributed to the development of sustainable One Health networks, using informal as well as formal approaches. In Ethiopia and Sierra Leone for example, our team made key contributions to the development of five-year National One Health Strategic Plans. Where PREDICT-2 country teams with One Health platforms are working across sectors to recognize the importance of conducting integrated surveillance and outbreak response at high risk animal-human-environment interfaces to prevent disease emergence.

Zoonotic disease detection and timely response are tightly linked to effective laboratory diagnostics for known and emerging disease threats. By building capacity for viral detection in all PREDICT-2 countries, capabilities for viral discovery and screening of viruses at the family level (both critical to expand detection platforms beyond testing for known and endemic pathogens) are positioned to live on and continue contributing to national and global health security beyond the life of the project. In Ethiopia, as in many PREDICT countries for example, university and ministry partners are actively engaged in zoonotic disease surveillance and laboratory diagnostics and are collaborating to put One Health in practice in both field and laboratory settings.

PREDICT/Ethiopia training EPHI staff and graduate students on conventional PCR techniques increasing the ability to screen for new and emerging disease threats.

Being responsive to in-country opportunities for innovative training and outreach in Asia and Africa

Training and capacity building activities often take place in a traditional or virtual classroom, but technical skills critical to health professionals are often best learned in the field or lab through instruction and hands-on application. During PREDICT-2, a variety of training approaches have been utilized, ranging from online trainings to face-to-face workshops and field activities. In an effort to foster One Health expertise using an innovative immersion experience format, PREDICT/Tanzania's Principal Investigator Professor Rudovick Kazwala worked with international and local partners to host more than 20 early career professionals from Africa, Asia, Europe, and the US in Tanzania during the one month *Rx One Health Summer Institute* in July 2018. Several PREDICT-2 staff participated in this transdisciplinary training experience, which utilized PREDICT-2

protocols and expertise to provide technical and hands on training in animal capture, biologic sampling, laboratory testing techniques, community engagement, and risk messaging. Following the course, participants reflected on the transformative nature of working with colleagues from around the world to understand and experience One Health topics over an extended period to integrate concepts and build global networks.

Dr. Brian Bird, Rx One Health guest lecturer, trains early career One Health professionals on how to safely and properly put on and off the appropriate equipment.

In August 2018, the PREDICT/Mongolia avian influenza surveillance team was notified about a large die-off of wild birds in Western Mongolia and joined government partners to investigate the event. PREDICT's field team collected samples from the affected area, which by the end of the month were undergoing testing at PREDICTs partner lab in Mongolia, the State Central Veterinary Lab, including testing using PREDICT's protocols for avian influenza and paramyxoviruses. Throughout the event, the PREDICT team shared information and recommendations on avian influenza and other potential diseases with government agency staff as well as local stakeholder groups, an opportunity to bridge animal and human health sectors and encourage data and information sharing.

PREDICT/Mongolia, Ulaankhuu Ankhanbaatar, performing viral testing on bird samples collected from the affected area for a local government agency in response to a potential avian influenza outbreak.

Making PREDICT training resources publicly available for health professionals

Select PREDICT-2 project training materials, protocols, and eBook resources are available to the public to encourage sharing of the knowledge and skills essential for safe and effective One Health surveillance, detection, and characterization of zoonotic disease threats. The materials and resources are accessible at this link.

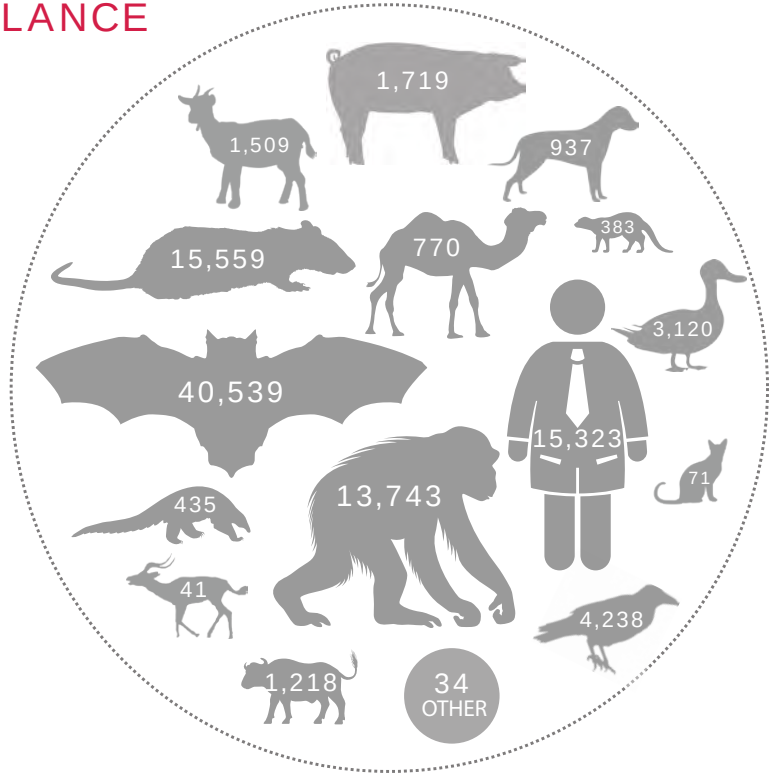
Publicly available Biosafety, Cold Chain and Emergency Preparedness Guides and Resources

- Basic Laboratory Safety (English-pdf, French)
- Biosafety and PPE Use (English-pdf, French)
- Emergency Preparedness (English-pdf, French)
- Implementing Cold Chain for Safe Sample Transport and Storage (English-pdf)
- Packing and Shipping Biological Samples (English-pdf)
- One Health Surveillance & Field Sampling Guides
- Avian Sampling Methods (English-pdf)
- Bat Sampling Methods (English-pdf, French)
- Bushmeat Sampling Methods (English-pdf)
- Livestock Sampling Methods (English-pdf)
- Non-Human Primate Sampling Methods (English-pdf)
- Rodent Sampling Methods (English-pdf)
- Safe Animal Capture and Sampling (English-pdf)
- Small Carnivore Sampling Methods (English-pdf)Behavioral Risk & Qualitative Research Guides
- Qualitative Research: Introduction & Observational Research Methods (English-pdf)
- Qualitative Research: Focus Groups, Ethnographic Interviews, & Data Analysis (English-pdf)

For more information or for information about other training resources, contact us at predict@ucdavis.edu

One Health Surveillance: Characterizing Biological & Ecological Risk

ONE HEALTH SURVEILLANCE



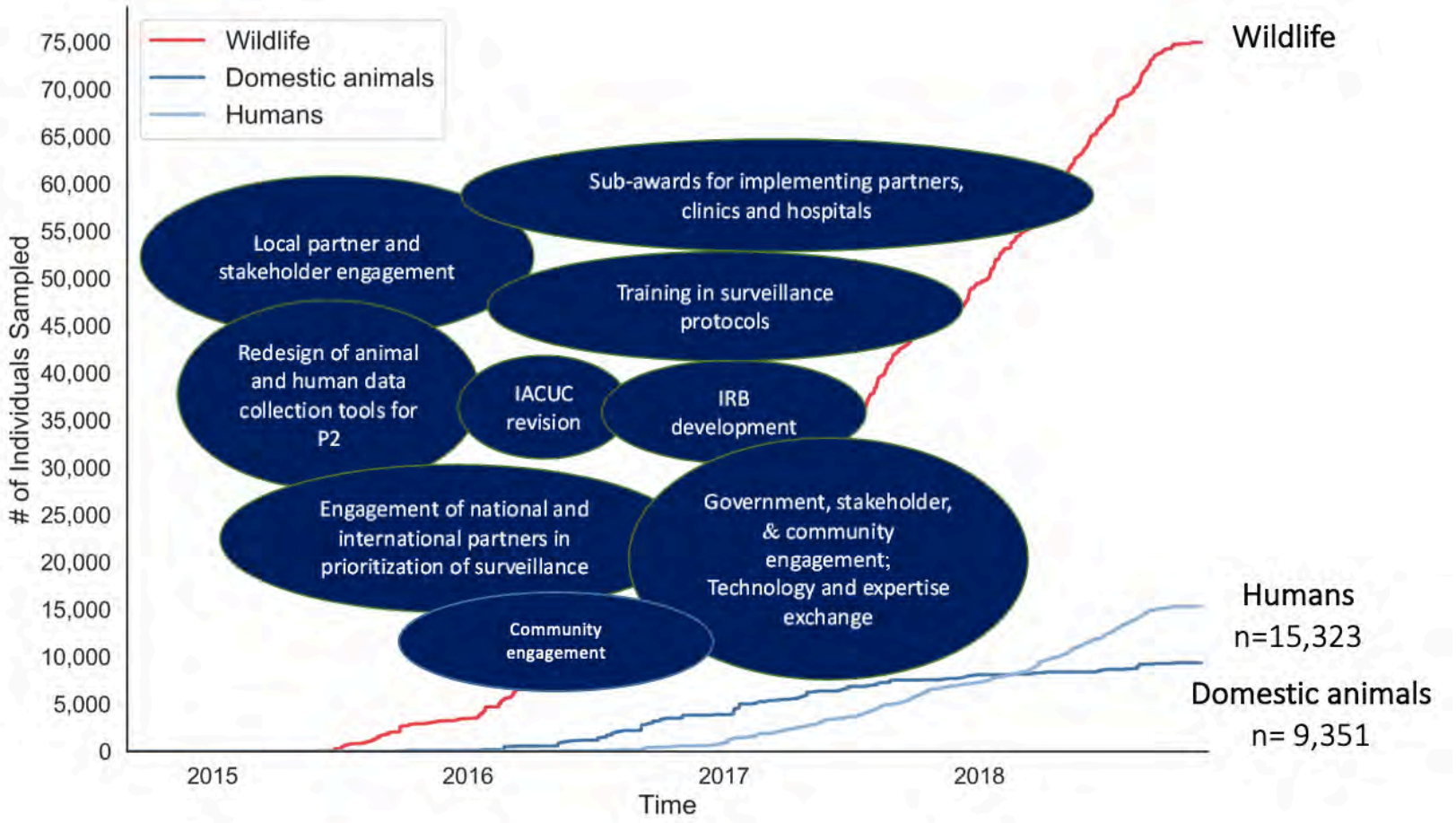
Overview

We completed implementation of our overall One Health surveillance strategy for animals and humans in coordination with USAID and Emerging Pandemic Threats-2 (EPT-2) partners to detect viruses in animals and humans, and characterize biological and ecological risk. Surveillance activities reinforced the importance of a concurrent surveillance strategy for detection of viral sharing and spillover as a result of close proximity interactions, or effective contact, between wildlife shedding viruses and susceptible people (and domestic species where relevant). For human surveillance, sampling targeted people with high-risk occupations at concurrent sites within a month of sampling animals, as well as sampling acutely ill patients year-round at clinic and hospitals within the catchment area of concurrent sites.

At the PREDICT Semi-annual Meeting in April 2018, we reviewed surveillance progress and accomplishments to date, and strategized successful completion of sampling and field activities in consensus with USAID and global and regional leads.

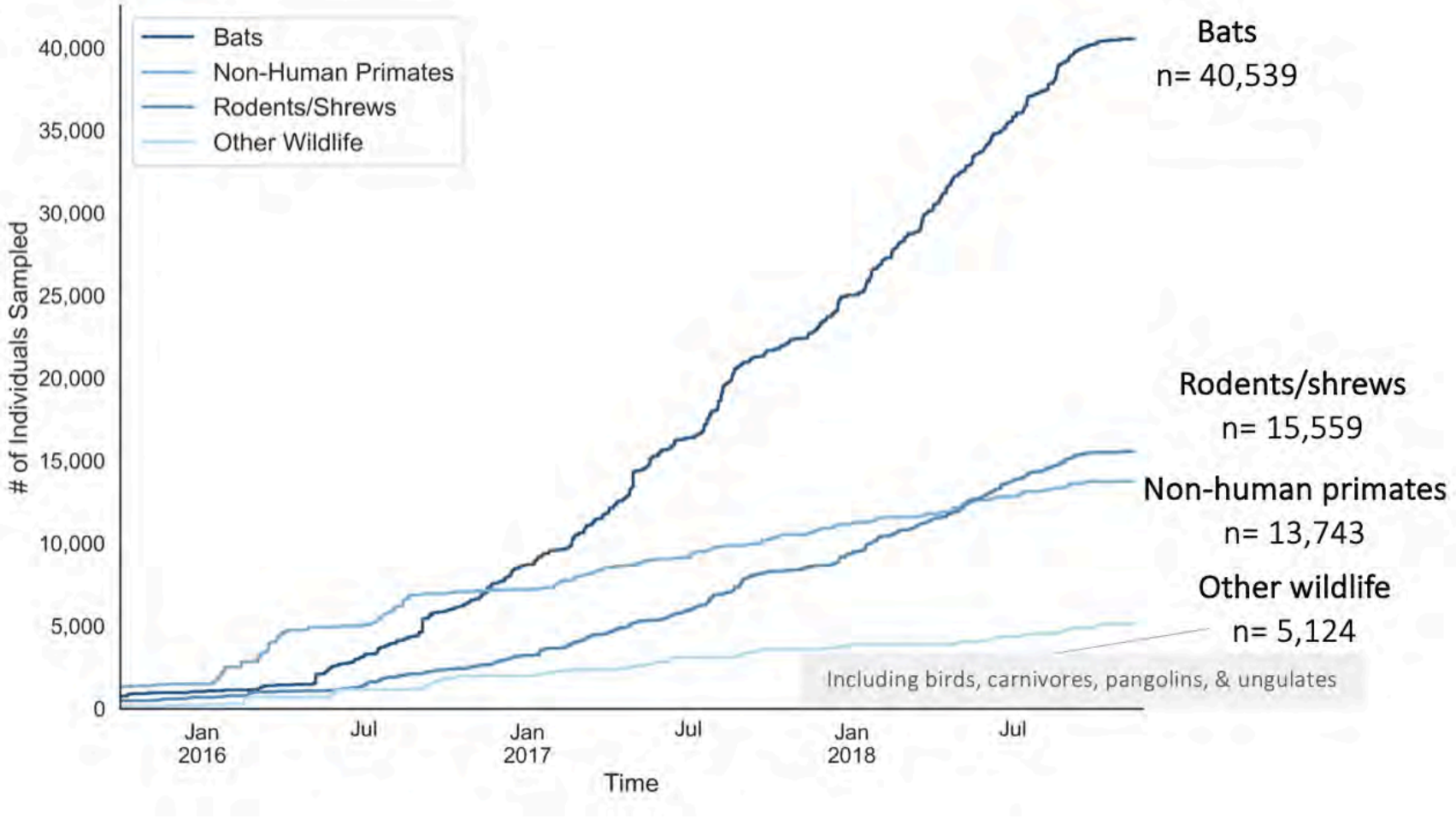
Targeted monitoring for zoonotic viruses with pandemic potential at specific high-risk interfaces

PREDICT has sampled over 84,000 animals and 15,000 people since the start of project activities in October 2014. Years 1-2 involved coordination of a multitude of required activities before sampling began in each country, including engagement of local partners and stakeholders, obtaining local and institutional permits for animal and human sampling, and staff training. Over the past year, field activities substantially ramped up with respect to sampling efficiency across wildlife, domestic animals, and humans (Figure 1). Sampling activities were completed in the majority of participating countries by the end of Year 4 (September 30, 2018).



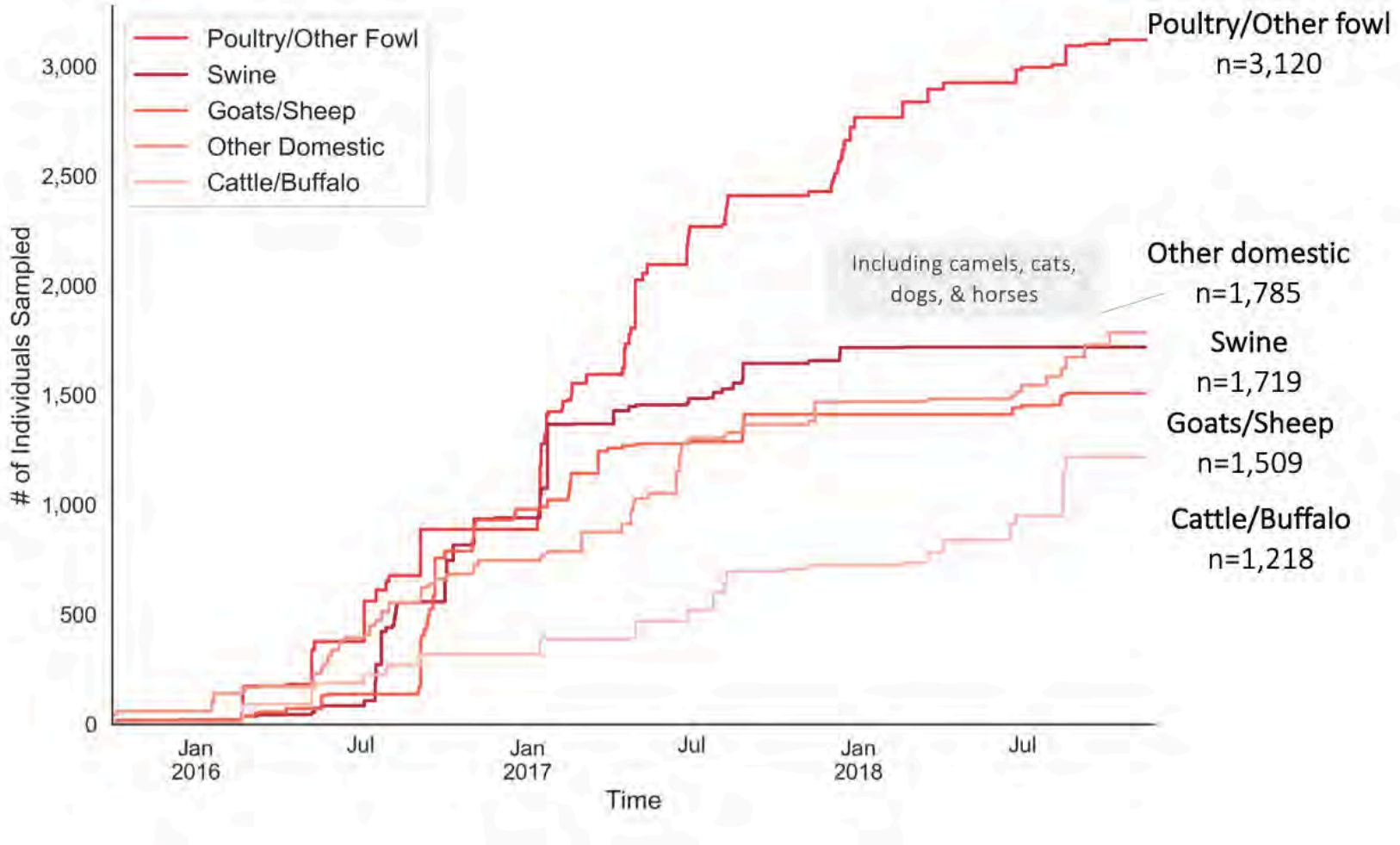
Wildlife

PREDICT made a substantial effort towards sampling targeted wildlife species, primarily bats, rodents, and non-human primates, at high-risk interfaces for zoonotic spillover and spread. Wildlife sampling activities at high-risk interfaces were implemented in all 28 PREDICT countries, which include: Bangladesh, Cambodia, Cameroon, China, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Ghana, Guinea, India, Indonesia, Jordan, Kenya, Lao PDR, Liberia, Malaysia, Mongolia, Myanmar, Nepal, Republic of Congo, Rwanda, Senegal, Sierra Leone, Tanzania, Thailand, Uganda, and Viet Nam.



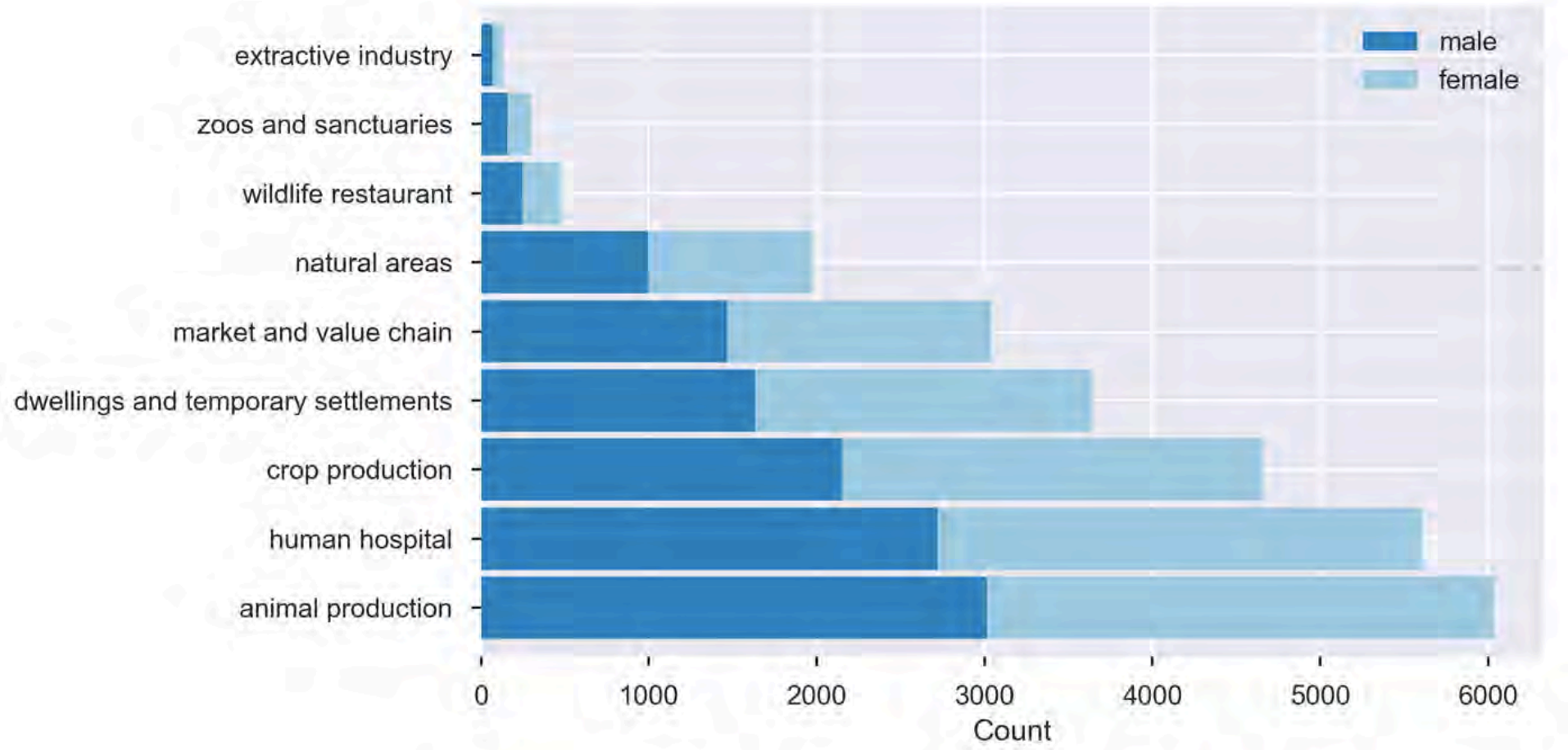
Livestock

PREDICT coordinated with FAO on planning and sampling livestock at sites designated for concurrent and triangulated surveillance wherever possible. Concurrent livestock sampling activities have been directly supported by FAO in Cambodia, Lao PDR, Myanmar, Nepal, and Viet Nam. Together with PREDICT teams, FAO undertook sampling of livestock concurrently with wildlife sampling (and human sampling where possible) in Egypt, Indonesia, Jordan, and Thailand. To date, PREDICT has completed additional livestock sampling in Bangladesh, Democratic Republic of Congo, Guinea, Sierra Leone, and Uganda. Due to the recent change in FAO priorities, livestock sampling was not prioritized further in Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Liberia, DR Congo, Republic of Congo, Rwanda, and Senegal.



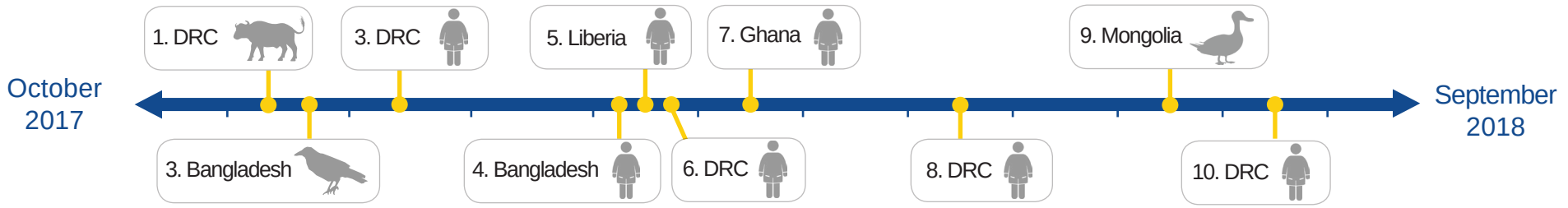
Humans

Human biological sampling and risk characterization surveys using PREDICT's human questionnaire were conducted in high-risk communities in 23 countries: Bangladesh, Cameroon, Cambodia, China, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Ghana, India, Indonesia, Jordan, Kenya, Lao PDR, Malaysia, Myanmar, Nepal, Rwanda, Senegal, Tanzania, Thailand, Uganda, and Viet Nam.



PREDICT-2 OUTBREAK SUPPORT

October 2017-September 2018



10 EVENTS

Mongolia
9. Bird die-off

Ghana
7. Human suspected Lassa fever

Bangladesh
2. Crow die-off
4. Human encephalitis

Liberia
5. Human diarrhea

DRC
1. Cattle die-off
3. Human encephalitis
6. Human suspected VHF
8. Human Ebola (Equateur)
10. Human Ebola (North Kivu)

N
520
Miles

Map production: PREDICT-2 Outbreak team, Resources: DIVA GIS

PREDICT-2 OUTBREAK SUPPORT

1. Democratic Republic of the Congo (DRC) Cattle die-off (Nov 2017)

Following reports of more than 4000 cattle with illness and death, PREDICT tested ten specimens for six viral families including the five priority families for PREDICT. Response to this event was coordinated and carried out by a multidisciplinary team including PREDICT, Ministry of Fishery and Livestock, FAO, and LABOVET.

2. Bangladesh Crow die-off (Nov 2017)

The PREDICT field team observed neurological symptoms and unusual mortality in crows in Dhaka city. Following government request for assistance, PREDICT collected samples from crows, provided technical advice, and tested specimens for five viral families. Routine work by the PREDICT team resulted in early detection of this unusual event, prompting quick and coordinated action. The field team was deployed one day after receiving request from the government.

3. DRC Human encephalitis (Dec 2017)

Two people presented with symptoms consistent with viral hemorrhagic disease in Bas-Uele and Kinshasa. PREDICT provided assistance with testing of specimens for all five priority viral families for PREDICT. The PREDICT team initiated laboratory testing on the same day that they received the specimens.

4. Bangladesh Human encephalitis (Feb 2018)

Two people in Bogradistrict presented with symptoms consistent with encephalitis, who had a history of drinking raw date palm sap. The PREDICT team was deployed to the outbreak site and collected 89 urine and 93 feces specimens from Pteropusbat roosts, half eaten palm fruit, as well as ecological information from the site. Specimens were tested for five priority viral families. The field team was deployed one day after receiving request from the government.

5. Liberia Human diarrheal illness (Feb 2018)

More than 60 people with diarrheal disease visited a clinic in MargibiCounty. PREDICT provided logistical support to the Liberian Ministry of Health to transport outbreak investigators and supplies to the affected area two days after they received the request.

PREDICT-2 OUTBREAK SUPPORT

6. DRC suspect human viral hemorrhagic fever (Feb 2018)

Two people from the same family developed symptoms consistent with viral hemorrhagic fever and died in Bas-Ueléprovince, Northern DRC. Following request from InstitutNational de RechercheBiomédicale (INRB), PREDICT tested clinical specimens using PREDICT priority virus family protocols. The PREDICT laboratory team completed testing two days after receiving the specimens.

7. Ghana suspect human Lassa fever (Mar 2018)

One person in the Greater Accra region developed symptoms consistent with viral hemorrhagic fever, which was suspected to be Lassa fever. PREDICT assisted with field investigation, and captured and sampled 52 rodents. The PREDICT team also collected ecological information at the outbreak site, and tested the specimens for five priority viral families..

8. DRC Human Ebola in Equateur province (May 2018)

Suspected cases of viral hemorrhagic fever, later confirmed as Ebola virus disease were reported in Equateur province, Western DRC. A total of 66 cases were notified from four health zones. PREDICT assisted with laboratory testing on patient specimens using the PREDICT viral family PCR protocols.

9. Mongolia Bird die-off (Aug 2018)

Local veterinarians reported a die-off of more than 3000 wild birds including Mongolian gulls and common shelducksaround SangiinDalai Lake in Govi-Altay province, Western Mongolia. No other taxa were affected. PREDICT provided technical assistance as part of regularly scheduled field surveillance activities.

10. DRC Human Ebola in North Kivu province (Aug 2018)

Suspected cases of viral hemorrhagic fever, later confirmed as Ebola virus disease were reported in North Kivu province, North Eastern DRC. As of December 4, 2018, approximately 440 confirmed cases and over 260 deaths have been reported. PREDICT supported partner organizations' outbreak activities by donating Personal Protective Equipment (PPE).

Characterizing Behavioral Risk

The goal of PREDICT's behavioral risk activities is to better understand behaviors that increase the risks of viral emergence, transmission, and spread and to use these data to inform the development of potential population or policy-level intervention strategies that could reduce the spillover, amplification, and spread of zoonotic viruses and other emerging threats. Highlights, success stories, and products from PREDICT behavioral risk activities are summarized below.

Highlights

- 732 professionals (46% women) in 29 countries have been trained on a variety of topics relevant to behavioral risk investigations.
- 11 training decks were developed to support capacity building sustainability.
- 6 tools were developed to enhance the rigor of mixed method behavioral risk characterization and intervention recommendation development.
- Over 1,000 ethnographic interviews and 100 focus groups (comprised of over 900 participants) have been conducted.
- Over 18,000 respondents have completed quantitative behavioral questionnaires.
- A behavior change risk reduction intervention tool entitled, *Living Safely with Bats* was developed to raise awareness about ways to reduce disease risks associated with human-to-bat contact. This picture book resource was piloted in Sierra Leone and Tanzania, and delivered by local partners in Sierra Leone, Guinea, and Liberia.

Success Stories

Behavioral Risk Mitigation Capacity Building in 28 Countries

A snapshot of global capacity building in connection with behavioral risk surveillance and characterization is shown in Figure 1. This included both remote and in-person trainings, as well as cross-team trainings to build regional capacity.

Figure 1. Behavioral Risk Surveillance Capacity Building efforts (through FY 2018)

Standardizing approaches to Studying Human Behavioral Risk

This year, PREDICT continued to develop, standardize, and refine behavioral risk protocols, frameworks, and tools to improve scientific rigor in data collection and analysis.

A Coding Clarification Log was maintained throughout the data collection process to increase the consistency, reliability, and validity of the questionnaire data collected. Clarifying questions that arose through out the data collection process were resolved through group discussion and consensus and added to the log to continuously improve the rigor of the data collection process.

The Questionnaire Analysis Matrix summarizes all data collection points associated with questionnaire administration, including the PREDICT's observation research tools (e.g., the site and event form and modules), as well as the human questionnaire and supplementary modules. The matrix further identifies items that may be directly or indirectly associated with risk and protective factors as they relate to knowledge/beliefs, attitudes, skills, and behaviors.

An Interim Data Review Report (IDR) displays key behavioral risk data in a user-friendly dashboard report format. The IDR prototype was refined and programmed into PREDICT's database (EIDITH) to give country teams access to their data in real-time and to support teams in their exploration of questionnaire data, while working towards the development of intervention recommendations *(Figure 2)*.

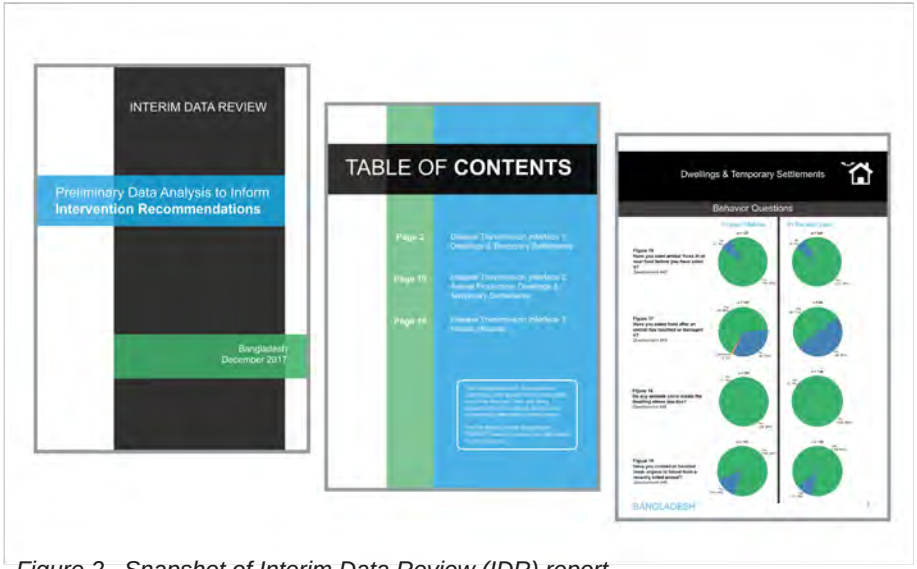
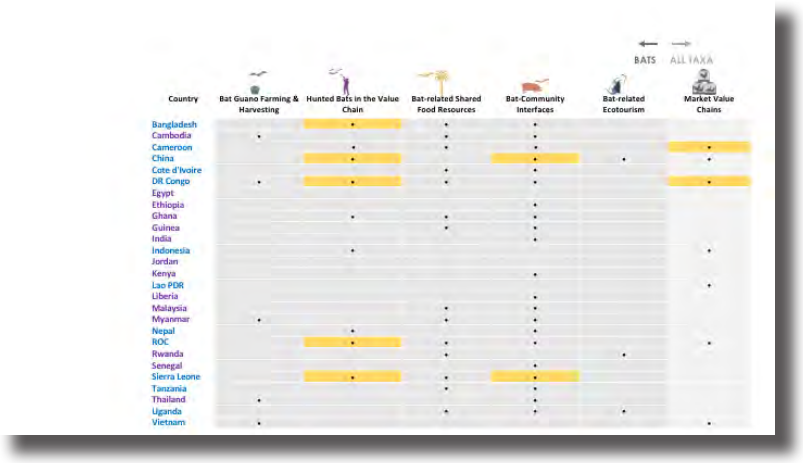


Figure 2. Snapshot of Interim Data Review (IDR) report

An **Intervention Development Tool** based on the risk and protective factors relevant to knowledge/beliefs, attitudes, skills, and behaviors, couched within a program evaluation 'logic model' framework facilitates program development and evaluation of desired processes and outcomes. An example of the template in the Intervention Development Tool used to capture risk and protective factors as they relate to behavior can be seen in *Figure 3*. The template for the end-goal logic model which incorporates these findings can be seen in *Figure 4.*



Development of the logic model and associated preliminary intervention recommendations, included:

- Qualitative analysis (as applicable)
- Quantitative analysis of questionnaire data
- Literature review
- Solicitation of subject matter expert (SME) input
- Collaboration across PREDICT technical teams to incorporate results
- Solicitation of international and local level feedback on draft recommendations
- Iterative and ongoing analysis and refinement of intervention recommendations

Figure 3. Example of Intervention Development Tool template for mixed methods analysis of risk and protective factors.

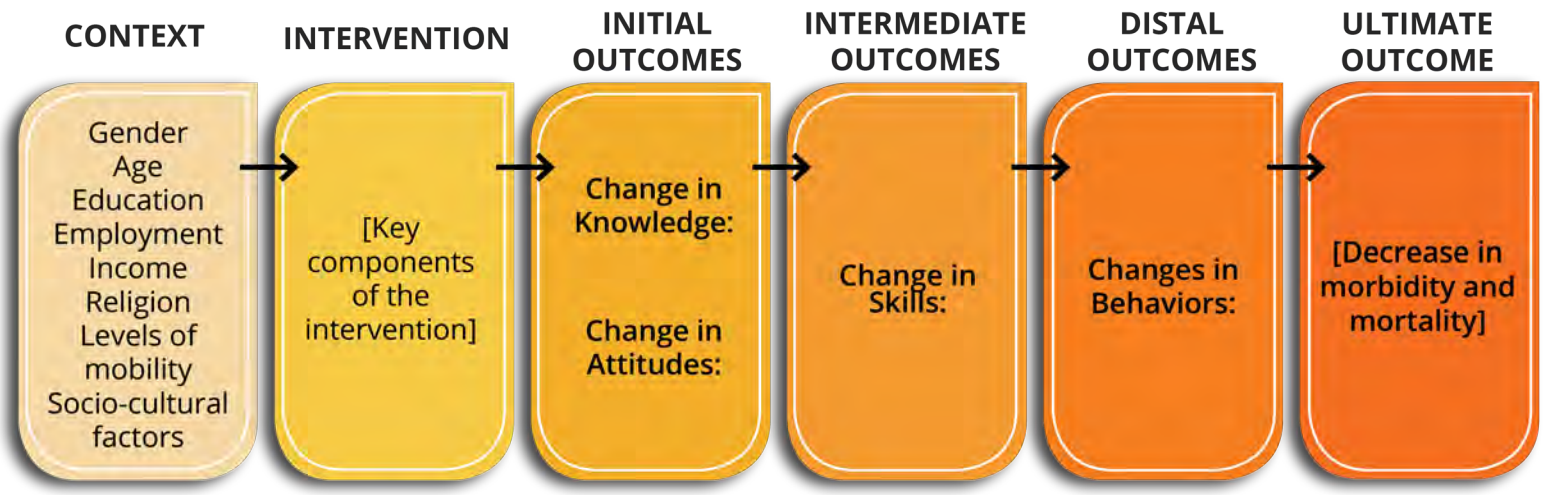


Figure 4. Example of Intervention Development Tool template for developing Logic Model that depicts intervention recommendations and associated desired outcomes.

Our team developed **training decks** to support rigor in quantitative and qualitative research which included:

- Goals and Objectives of Behavioral Risk SurveillanceQualitative Data Collection
- Qualitative Coding, Thematic Analysis, and Results Synthesis
- Surveillance of High-Risk Human Populations
- 'Ebola Host Project': Behavioral Risk Surveillance and Characterization in West Africa
- EIDITH Database and Data Entry
- EIDITH Test Results Uploading
- Intervention Recommendation Development
- Introduction to MaxQDA
- Introduction to R/R Studio
- Introduction to Manuscript Development

We developed a **Training Tracker** that inventoried training needs across all 28 country teams to improve the coordination, efficiency, and reach of capacity building efforts.

Analysis planning resources were created consisting of a framework and prototype to support analysis planning across behavioral risk teams and across consortium technical teams towards the development of holistic multi-disciplinary One Health interventionrecommendations.

Identifying Potential Intervention Points

Deep Dive Investigations. Preliminary analyses of project data revealed that bat-related interfaces warrant particular attention given the connection between bats and pandemics, such as SARS and Ebola. Further, PREDICT detected numerous viruses in bats at high-risk interfaces, including coronaviruses, paramyxoviruses, and influenza viruses.

PREDICT's One Health teams have the potential to make a significant contribution to the prevention of bat-related zoonotic pandemics given the current lack of risk reduction tools and higher risk represented by this taxa. Market value chains also warrant unpacking, given the complexity of multiple components. As such, PREDICT continued to conduct in-depth investigations into the deep dive topics shown in Figure 5.

Ongoing and planned data collection efforts by deep dive topic are shown in *Figure 6.* Early insights into intervention recommendations have been drafted across six countries (nine deep dive topics total). In terms of qualitative data collection to date, the team has conducted over 1,000 ethnographic interviews and 100 focus groups (comprised of over 900 participants). In addition, quantitative questionnaires have been administered ~18,000 participants. Behavioral risk data collected to date is shown in *Figure 7*.

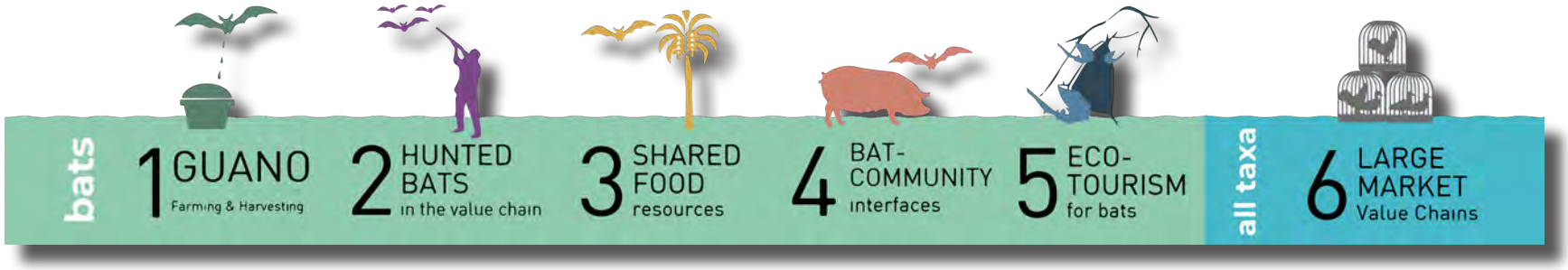


Figure 5. Behavioral Risk Deep-Dive Topics.

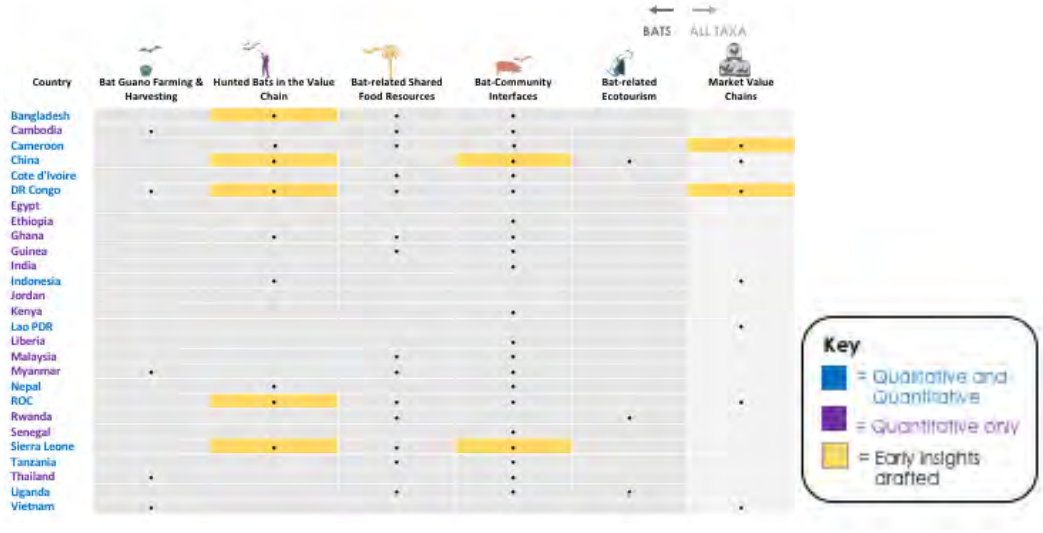


Figure 6. Ongoing data collection on Deep Dive topics by country

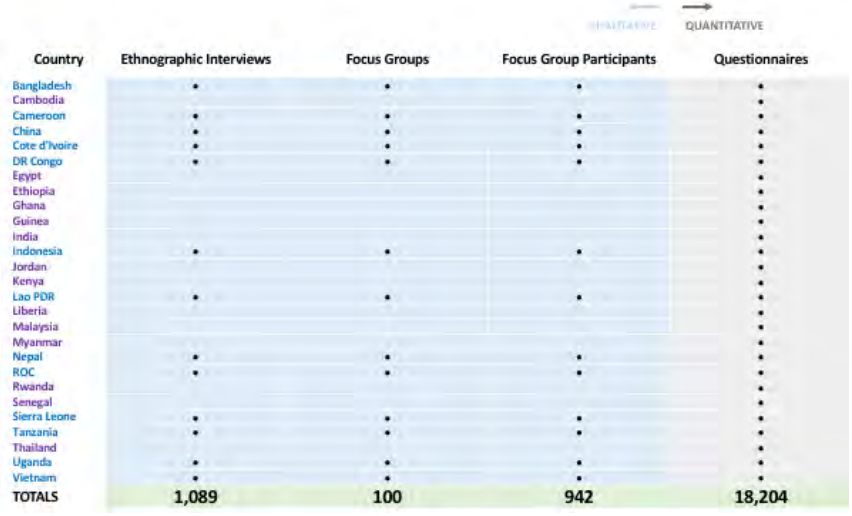


Figure 7. Behavioral risk data collection through FY 2018.

Integration of Modeling and Analytics Findings. The PREDICT Modeling and Analytics technical team is leading the implementation of modeling efforts referred to as 'IMPACTs' (Intervention Modeling Projects Across Teams). These IMPACT projects are designed to output modeling results that can be integrated into the development of intervention recommendations for each deep dive topic.

Behavioral Risk Team Products

- Risk reduction behavior change resource, "Living
- Safely with Bats" picture book
- Coding Clarification Log
- Questionnaire Analysis Matrix
- Real-time Interim Data Review (IDR) report
- Intervention Development Tool
- 11 training decks to support capacity building sustainbility
- Training Tracker
- Analysis planning resources
- GIS mockups depicting behavioral data

Mrs. Djeneba Bamba and Dr. Eugène Koffi work together to characterize the zoonotic disease transmission risk at a planned surveillance site in Asproa in January 2018. Photo: PREDICT/CIV.

Information Management

Strengthening One Health data platforms

The Emerging Infectious Disease Information and Technology Hub (EIDITH) Surveillance Data Collection Application was continually optimized to improve efficiency and scope and for integration with EPT-2 Monitoring and Evaluation indictors for improved data capture, quality assurance, and reporting functionality. These improvements included a new dashboard filter to allow users to filter their events by event name, modules for event status fields, and a new filter inside the event data entry form to filter by incomplete forms only, thus improving workflow efficiency. Test result data entry functionality was also expanded to include serology test results. A new dashboard to allow laboratory teams to upload animal barcoding test results for samples from both PREDICT-1 and PREDICT-2 was also added to the application, thus improving species data accuracy throughout the EIDITH database.

Additions and improvements were also implemented on the EIDITH website, including a new mapping tool to track the locations where individuals who were interviewed live (though no personal identifying information is linked to this spatial data), a new graphing tool to track lab progress, and a new data extract for positive viral findings, all of which assist in progress tracking for our teams and scientists at the country level.

Finally, four new reports were developed to help improve PREDICT laboratory team tracking and workflow: *Number of Animals/Humans Tested, Number of Specimens Tested, Number of Tests by Month, and Number of Individuals Sampled with Specimens Collected.*

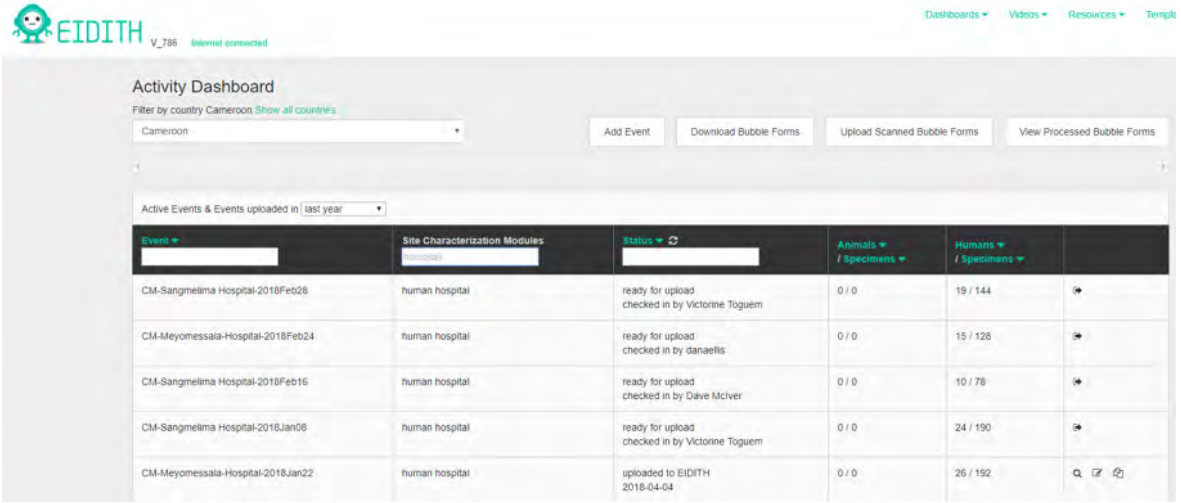


Figure 1. EIDITH's event dashboard showing only PREDICT sampling events that include the human hospital module, which is administered to patients enrolled in clinics and hospitals for biological sampling and behavioral risk questionnaires.

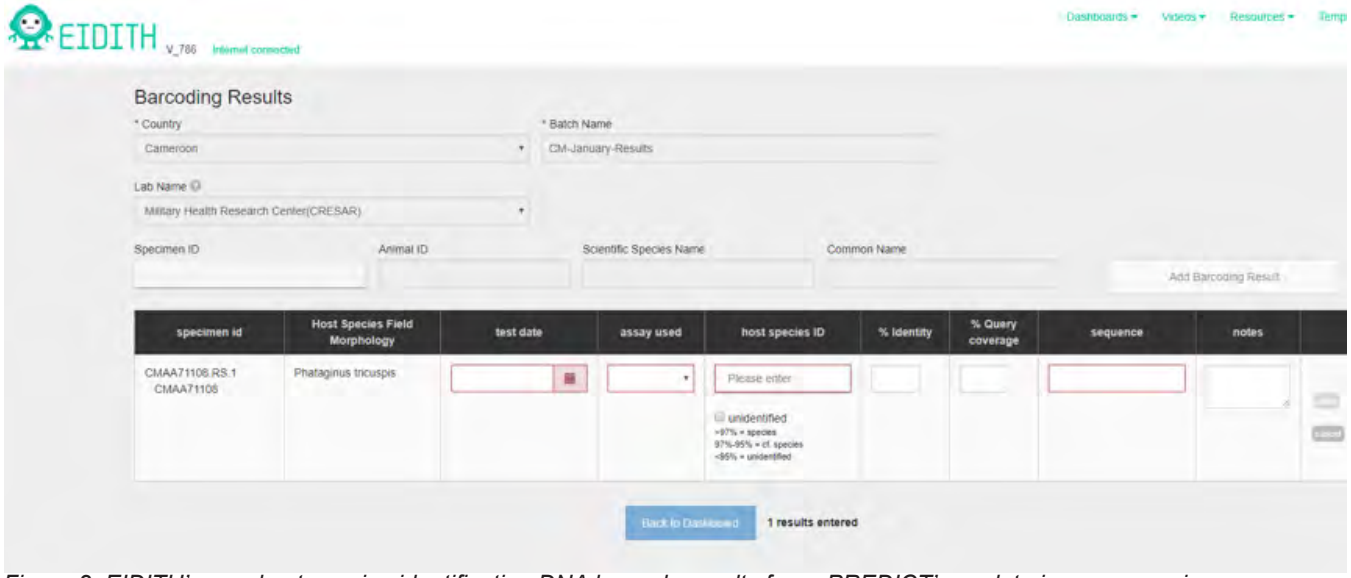


Figure 2. EIDITH's new host species identification DNA barcode results form. PREDICT's work to improve species identification for wild animals is helping strengthen our understanding of animal hosts of viral threats and provide valuable information on species range and distribution for the international conservation and biodiversity communities.

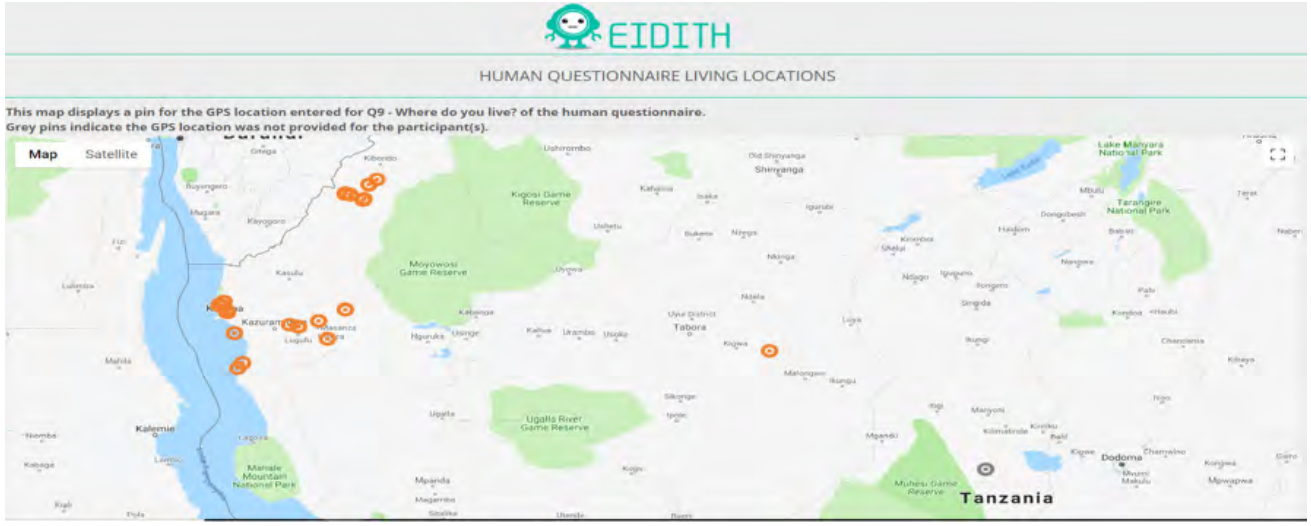


Figure 3. EIDITH's new Living Locations mapping tool, which displays all spatial locations of people who completed behavioral risk interviews.

To enable paper-based data collection and rapid digitization in situations for which digital data collection is not optimal, optical mark recognition (bubble) forms are used by our teams to collect data. Our challenge however, was developing bubble forms for use in required project languages across all 28 participating countries. Translation of the human questionnaire into local languages continued throughout this reporting period (Thai, Amharic, and Malay languages to name a few recent language packages added to our forms), thereby enabling field teams the ability to conduct interviews in their local languages, and rapidly digitize data for use in risk analysis and characterization efforts.

Figure 4. EIDITH's Human Questionnaire Bubble Form was translated into Thai, one of the new language packs added this period.

We continued to support PREDICT's Capacity Strengthening team by improving systems for monitoring trainings. The EIDITH *Training Application* was optimized this period to include new data entry forms for tracking multiple-person trainings such as lectures, large group workshops, and short courses. These forms capture one-time training events for persons involved in PREDICT activities, but who are not necessarily PREDICT staff, partners, or collaborators. Improvements were also made to enable alerts for project staff to complete refresher training when core trainings in PREDICT modules are nearing expiration, a feature that enables tracking of training status for our project staff that are often on the front lines of disease surveillance and engaged in activities with high occupational risk. Refresher trainings also help strengthen staff familiarity and mastery of protocols and techniques, an essential element for assuring safety in challenging field and lab settings.

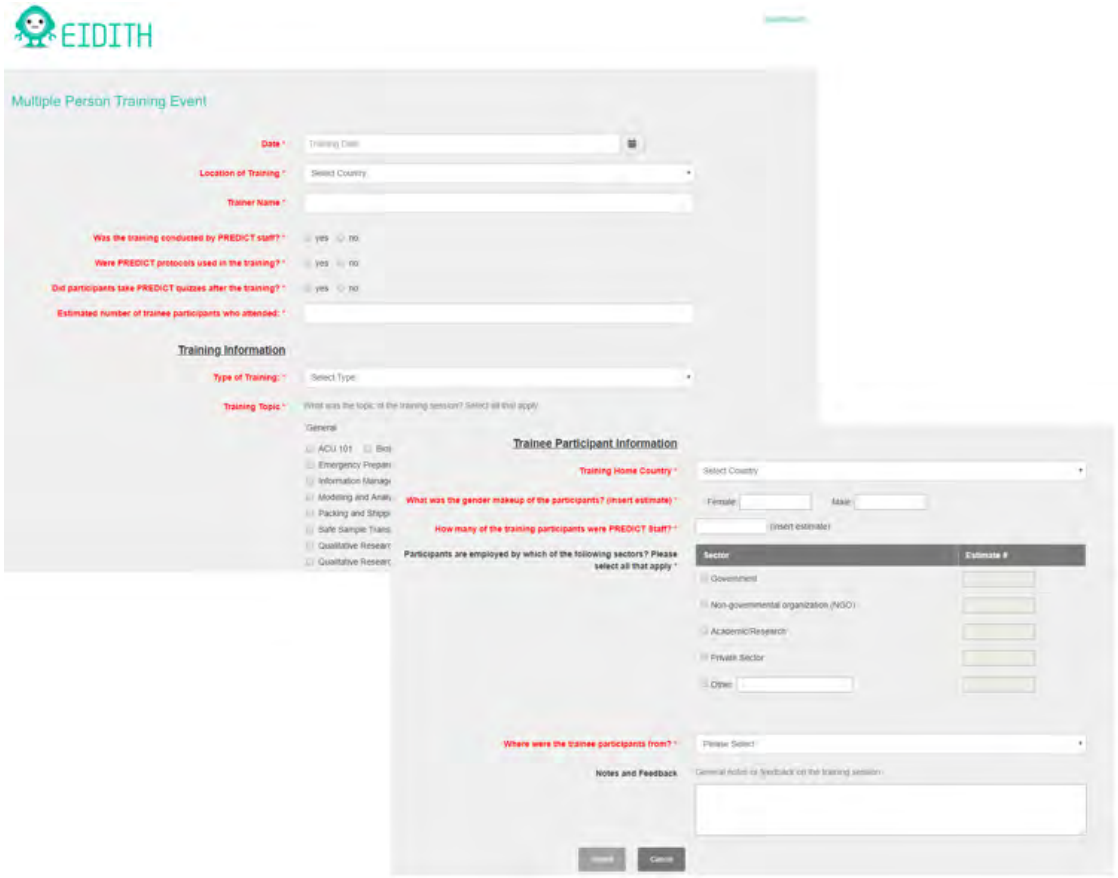


Figure 5. A screenshot of the new multiple person training data entry form.

Finally, PREDICT's HealthMap-hosted public site, available at http://data.predict.global, was revised to provide a new map layer combining PREDICT-1 and PREDICT-2 data into a single view. This new integrated layer enables the visualization of data from the entire life of the project. In addition, we created a tool that extracts select PREDICT data directly from the EIDITH database and pushes it into HealthMap, providing real-time map views for training, surveillance, and viral findings (restricted to viral findings approved for public release) data layers.

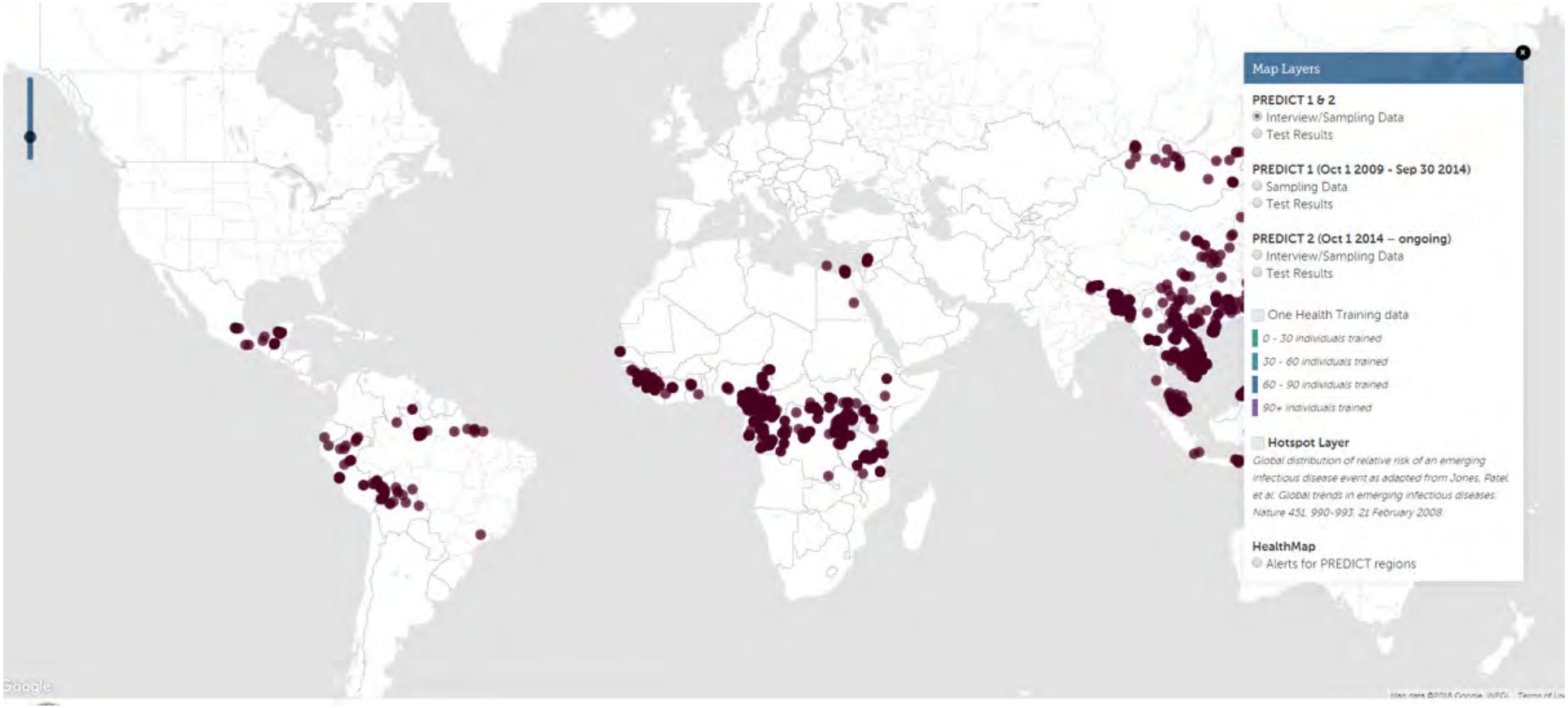


Figure 6. A screenshot of PREDICT's updated public site showing combined PREDICT-1 & PREDICT-2 data. The site is available at http://data.predict.global

Virus Table. Viral findings approved for release by country, taxa, year, and season indicating the number of positive individuals for each virus detected

Country	Virus	Taxa	2015		2016		2017		2018	
			Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Bangladesh	Influenza A	Bats				35	13	4		
		Birds			119		82			
		Camels		13		5		1		
		Goats/sheep		1		4		2		
		Non-human primates			2		3			
		Poultry/other fowl			10		45			
		Rodents/shrews			7	17				
	Newcastle Disease Virus	Poultry/other fowl					2			
	Peste des petits ruminants (PPR)	Goats/sheep		2				2		
	PREDICT_CoV-17	Bats							4	
	PREDICT_CoV-52	Bats				1		2		
	PREDICT_CoV-56	Bats				5				
	PREDICT_CoV-86	Bats				1				
	PREDICT_CoV-88	Bats				4				
	PREDICT_CoV-89	Bats				1				
	PREDICT_CoV-90	Bats				3				
	PREDICT_PMV-103	Bats				1				
	PREDICT_PMV-104	Bats				1				
	PREDICT_PMV-109	Bats				1				
	PREDICT_PMV-20	Rodents/shrews				5				
	strain of Alphacoronavirus 1	Dogs					2			
	strain of Avian Paramyxovirus 6	Poultry/other fowl					7			
	strain of Duck Coronavirus	Poultry/other fowl					37			
	strain of Infectious bronchitis virus (IBV)	Birds					3			
		Poultry/other fowl					29			
	strain of Murine coronavirus	Rodents/shrews			1					
	strain of Newcastle Disease Virus	Poultry/other fowl					20			
	strain of Pigeon-Dominant Coronavirus	Poultry/other fowl					9			
Cambodia	PREDICT_CoV-25	Bats		1						
	PREDICT_PMV-13	Bats		6						

	PREDICT_PMV-63	Bats	1				
	PREDICT_PMV-66	Bats	3				
	PREDICT_PMV-67	Bats	9				
	PREDICT_RbdV-21	Bats	1				
	PREDICT_RbdV-28	Bats	1				
	PREDICT_RbdV-31	Bats	2				
	PREDICT_RbdV-32	Bats	1				
	PREDICT_RbdV-33	Bats	1				
	Strain of Bat coronavirus 512/2005	Bats	2				
	Strain of Lonquan Aa mouse coronavirus	Rodents/shrews	37				
	Strain of Murine coronavirus	Rodents/shrews	70				
	Thottapalayam virus	Rodents/shrews	2				
Cameroon	Monkey pox	Environmental sample		7			
		Non-human primates		5			
	PREDICT_CoV-30	Bats	1				
	PREDICT_CoV-35	Bats	2				
	PREDICT_CoV-44	Bats		1	2	1	3
	PREDICT_CoV-54	Bats			10	3	
	PREDICT_CoV-66	Bats	2				
	PREDICT_CoV-75	Carnivores		1			
	PREDICT_CoV-81	Bats		11	3	3	1
	PREDICT_PMV-101	Rodents/shrews			3	1	
	PREDICT_PMV-127	Bats			1		
	PREDICT_PMV-131	Rodents/shrews				1	
	PREDICT_PMV-133	Bats				1	
	PREDICT_PMV-79	Bats		2			
	PREDICT_PMV-80	Bats		1	1		
	PREDICT_PMV-82	Bats		1			
	PREDICT_PMV-91	Rodents/shrews		1			
	PREDICT_PMV-97	Bats		1			
	Strain of Bat coronavirus Hipposideros	Bats					1
	Strain of Human Coronavirus 229E	Bats		16	4	15	3
	Strain of Zaria Bat Coronavirus	Bats			2	8	
China	Influenza A	Humans	3				
	PREDICT_CoV-22	Bats		11		32	

	PREDICT_CoV-23	Bats				1	
	PREDICT_CoV-79	Bats			8	29	
	PREDICT_CoV-95	Bats				2	
	PREDICT_PMV-123	Bats				1	
	PREDICT_PMV-129	Bats				1	
	PREDICT_PMV-130	Bats				1	
	PREDICT_PMV-134	Bats				1	
	PREDICT_PMV-135	Bats				1	
	PREDICT_PMV-136	Bats				1	
	PREDICT_PMV-47	Bats				3	
	PREDICT_PMV-49	Bats			1	1	
	PREDICT_PMV-88	Bats			1		
	PREDICT_PMV-89	Bats			1		
	PREDICT_PMV-90	Bats			1		
	Strain of Bat Coronavirus 1	Bats			32		
	Strain of Bat Coronavirus HKU10	Bats			6		
	Strain of Bat coronavirus HKU2	Bats			3	28	
	Strain of bat coronavirus HKU6	Bats				44	
	Strain of Bat coronavirus HKU8	Bats			3		
	Strain of Bat coronavirus HKU9	Bats				6	
	Strain of Bat paramyxovirus isolate BtHp-ParaV/GD2012	Bats				2	
	Strain of Hipposideros_Bat_Alphacoronavirus_ MJ/67C	Bats				2	
	Strain of Rhinolophus/Hipposideros Alphacoronavirus	Bats			1		
	Strain of SARS-related betacoronavirus Rp3/2004	Bats				14	
	Strain of SARS-related betacoronavirus RsSHC014	Bats			1		
DR Congo	Ebolavirus (EBOV-Zaire)	Humans					1
	Strain of Bat coronavirus Hipposideros	Bats		1			
	Strain of Eidolon bat coronavirus/Kenya/KY24/2006	Bats			8		
	Strain of Kenya bat coronavirus/BtKY56/BtKY55	Bats	1		2		
	Strain of Pan paniscus lymphocryptovirus 1	Non-human primates		2	2		
Egypt	PREDICT_PMV-113	Bats		1			
	PREDICT_PMV-114	Bats				1	
	PREDICT_PMV-115	Bats				1	
	PREDICT_PMV-116	Bats				1	
	PREDICT_PMV-118	Bats		12			

	PREDICT_PMV-119	Bats			1					
	Strain of Bat coronavirus HKU9	Bats						6		
	Strain of Rousettus Bat Coronavirus/NRC-1	Bats						4		
	Strain of Rousettus Bat Coronavirus/NRC-2	Bats						8		
Jordan	PREDICT_CoV-65	Bats					5			
	PREDICT_CoV-91	Bats					1			
	Strain of Bat Alphacoronavirus/GS2013/HuB2013	Bats					5			
	Strain of Bat Coronavirus BM48-31/BGR/2008	Bats					28			
	Strain of Bat coronavirus HKU9	Bats					2			
	Strain of Betacoronavirus 1 (OC43)	Bats					1			
	Strain of Human Coronavirus 229E	Bats					17			
Lao PDR	Strain of Lonquan Aa mouse coronavirus	Rodents/shrews			2					
Malaysia	Strain of Infectious bronchitis virus (IBV)	Poultry/other fowl				1				
	PREDICT_CoV-52	Bats		1		5				
	PREDICT_CoV-76	Bats		3						
		Rodents/shrews		1						
	PREDICT_CoV-78	Bats	2	7	1	1			4	1
		Rodents/shrews		1		1				9
	PREDICT_CoV-80	Bats	3							
	PREDICT_CoV-84	Bats		1		1		1		
	PREDICT_Flavi-6	Bats				2				
	PREDICT_PMV-105	Bats		1						
	PREDICT_PMV-106	Bats				2				
	PREDICT_PMV-107	Bats				2				
	PREDICT_PMV-108	Bats				1				
	PREDICT_PMV-110	Bats				1				
	PREDICT_PMV-120	Other			1					
	PREDICT_PMV-137	Bats							1	
	PREDICT_PMV-72	Bats		2						
	PREDICT_PMV-74	Bats			1	1				
	PREDICT_PMV-81	Bats		4						
	PREDICT_PMV-98	Bats				1				
	PREDICT_PMV-99	Bats				1				
	Strain of Murine coronavirus	Rodents/shrews		1		1			1	
	Strain of Philippines/Diliman1525G2/2008	Bats					1			

Mongolia	Influenza A	Birds		31	15		
Myanmar	PREDICT_CoV-47	Bats			2		
	PREDICT_CoV-82	Bats			3		
Nepal	Influenza A	Birds	12				
		Humans			10		
	PREDICT_PMV-83	Rodents/shrews	1				
	Strain of Duck Coronavirus	Birds	25				
	Strain of Infectious bronchitis virus (IBV)	Birds	3				
	Strain of Murine coronavirus	Rodents/shrews	4				
	Strain of Newcastle Disease Virus	Birds	8				
Rwanda	PREDICT_CoV-44	Bats		7			
	PREDICT_CoV-77	Bats		1			
	PREDICT_CoV-94	Rodents/shrews					2
	PREDICT_PMV-56	Bats			1		
	Strain of Chaerephon bat coronavirus/Kenya/KY22/2006	Bats		1			
	Strain of Eidolon bat coronavirus/Kenya/KY24/2006	Bats			19	1	
	Strain of Human Coronavirus 229E	Bats		2			
	Strain of Kenya bat coronavirus BtKY33/2006	Bats		1			
Sierra Leone	Bombali virus	Bats				5	
Thailand	Nipah Virus	Bats				2	
	PREDICT_CoV-17	Bats				13	
	PREDICT_CoV-22	Bats		7			
	PREDICT_CoV-27	Bats		3			
	PREDICT_CoV-47	Bats		5		6	
	PREDICT_CoV-68	Bats				9	
	PREDICT_PMV-2	Bats				4	
	PREDICT_PMV-20	Rodents/shrews				2	
	PREDICT_PMV-85	Bats				1	
	PREDICT_PMV-86	Rodents/shrews				2	
	Strain of Bat Coronavirus 1	Bats		1			
	Strain of Murine coronavirus	Rodents/shrews				9	2
Vietnam	Influenza A	Swine				26	
	Strain of Porcine Parainfluenzavirus 1	Swine	1			2	

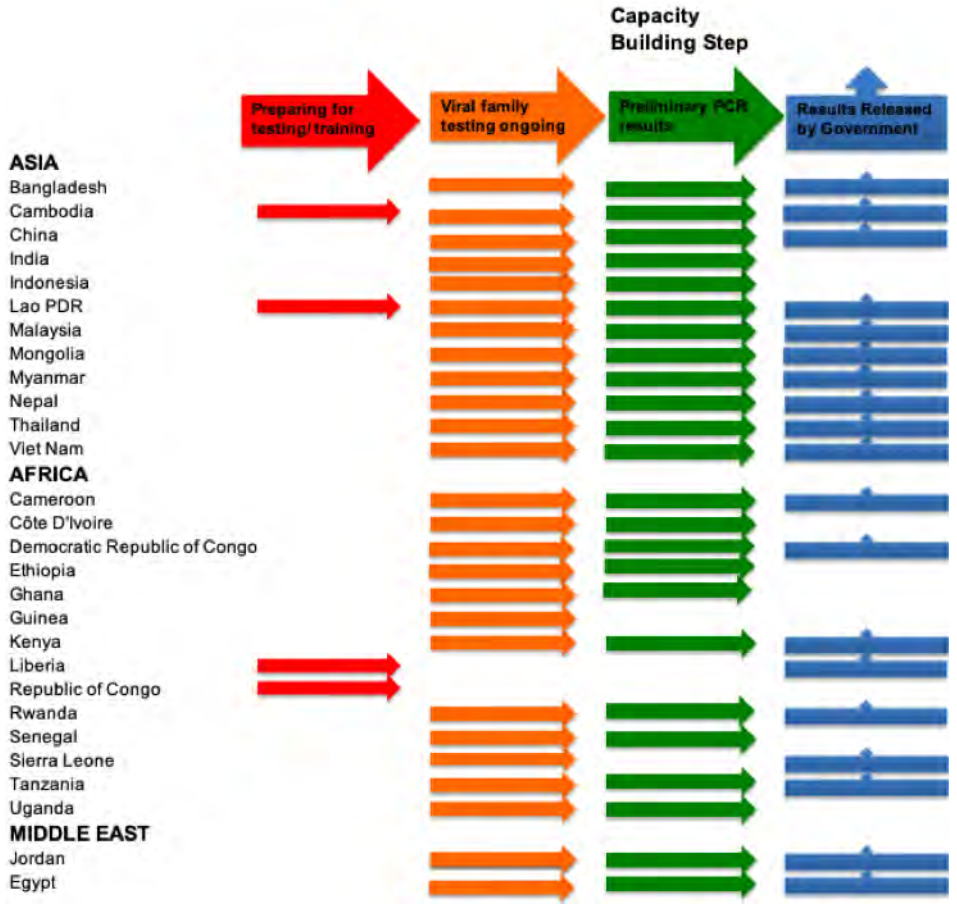
Viral Detection & Lab Implementation

Laboratory capacity-building

PREDICT continued to improve disease detection capabilities in 63 laboratories, which were targeted for training and testing across five priority viral families (corona, paramyxo, filo, influenza, and flaviviruses) known to cause zoonotic disease in humans and that are considered pandemic threats. There are now 41 labs testing for one or more priority viral families across Asia and Africa. During this period, 28 labs gained a one or two step increase in detection capacity (Figure 1): 13 gained a one-step increase and 15 gained a two -step increase. As a result, four labs began training/ preparing for testing, nine labs began testing for the first time, 10 additional labs produced preliminary results for the first time, and 21 labs submitted sequence results for interpretation.

Result reporting also increased and viral findings have been approved for public released by host country governments in 48 reports from 18 countries (see summary of major milestones in laboratory testing). Results reports were prepared for 14 countries and will be shared or have been shared with government partners soon. All government approved results are available on our public site at www.data.predict.global.

Summary of major milestones in laboratory testing by country



PREDICT viral interpretation results*

Viral Family	Number of known viruses found in P1	Number of novel viruses found in P1	Number of additional known viruses found in P2	Number of additional novel viruses found in P2	Total
Coronavirus	31	69	17	25	142
Paramyxovirus	12	74	7	65	158
Filovirus	0	0	0	1	1
Influenza virus	8	0	1	0	9
Flavivirus	3	5	3	1	12
Hantavirus	4	3	1	0	8
Rhabdovirus	0	31	0	3	34

*Some findings not yet approved for release; data for other viral families detected during PREDICT-1 not shown

***Definition of a new virus:** A virus is considered to be new if it has equal or greater genetic variation than the difference between the two closest known virus species within a family/genus and if it represents a distinct (monophyletic) lineage. Our data are strongly suggestive of a new virus but such classification can only be conferred by the International Committee on Taxonomy of Viruses (ICTV).

****Assessment of risk:** Results and their interpretation are provided on an individual test basis. Assessments of risk to public and animal health are based on what we know to be true for known viruses and relatedness of the viruses detected here to those known viruses. Further characterization is needed of novel viruses understand if these viruses pose a threat to human health

Technicians receive training in Cote d'Ivoire at LANADA and Institute Pasteur laboratories. In total six technicians received bench top laboratory training to perform PREDICT viral family testing, and 18 people received classroom-based training on emerging infections diseases, the PREDICT testing strategy, and EIDITH data entry. Isa Navarrete-Macias (pictured) and Heather Wells traveled from Columbia University to perform the training.

Testing Progress

An updated side by side comparison shows that we are on track with testing at this stage of the project compared with PREDICT-1, as a similar number of individuals have been tested through September 2018 (Figure 1). Given the expanded scope for PREDICT-2, we estimate we are still on track for a timely completion of testing by the end of March 2019. The majority of samples tested continue to be from bats, rodents, and humans (Figure 2).

Comparison of the number of positives detected in PREDICT-1 and PREDICT-2 also shows a greater number of positive individuals at this stage of the project (Figure 3). We attribute this to our revised PREDICT-2 strategy and investments in laboratory capacity strengthening.

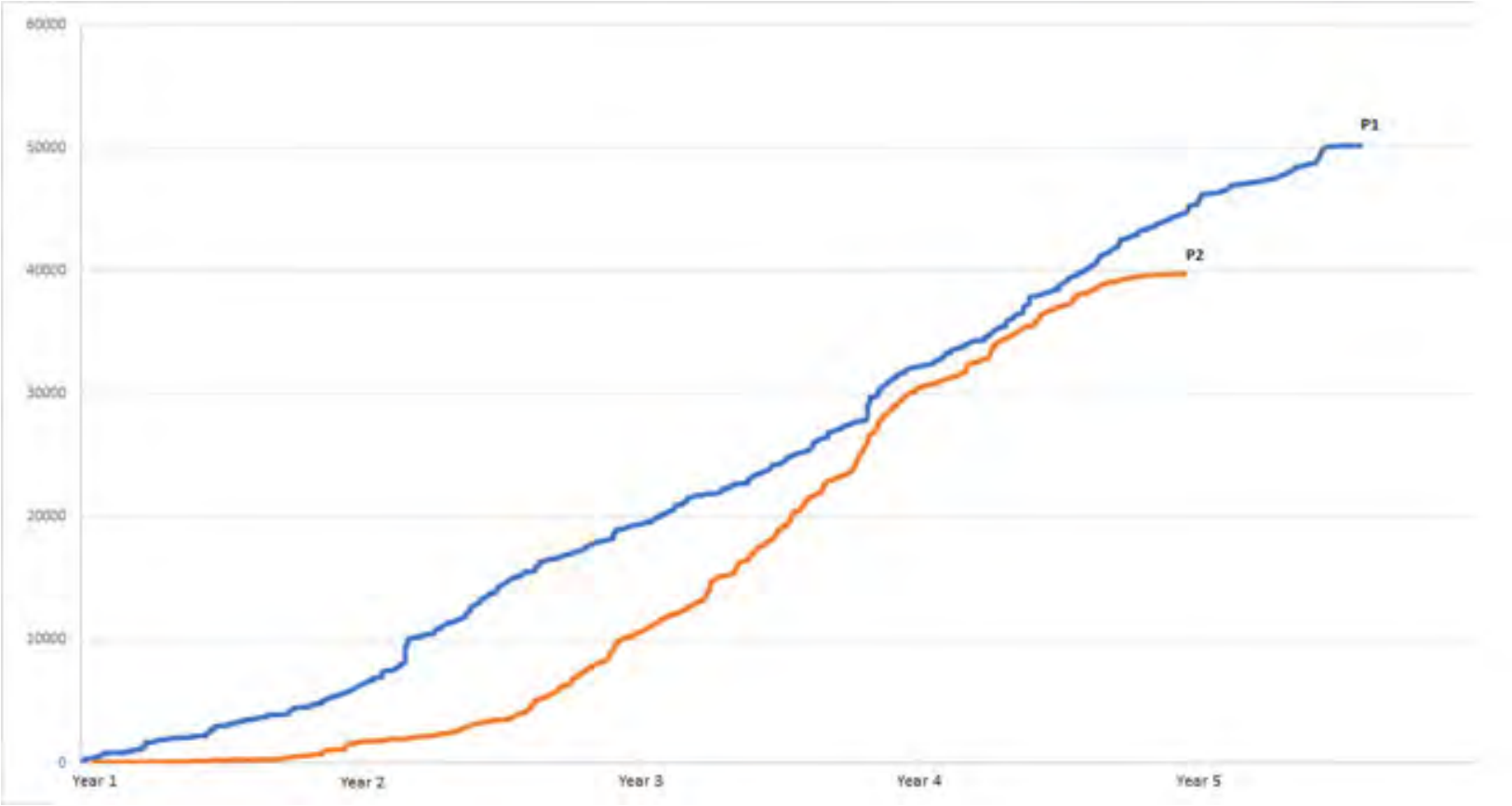


Figure 1. Total number of individuals tested in PREDICT 1 (blue line) and PREDICT 2 (orange line).

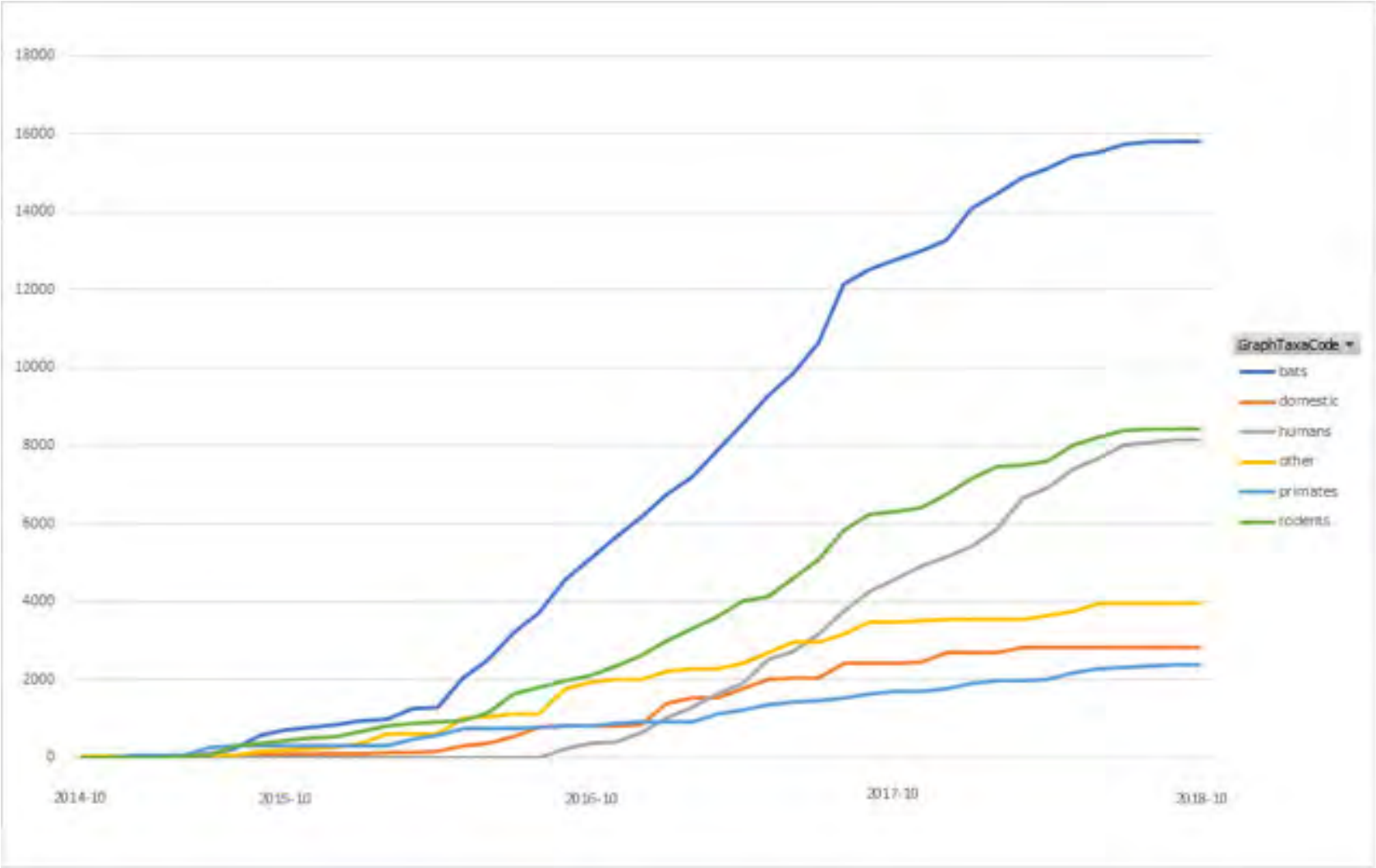


Figure 2. Total number of individuals tested to date broken out by taxa.

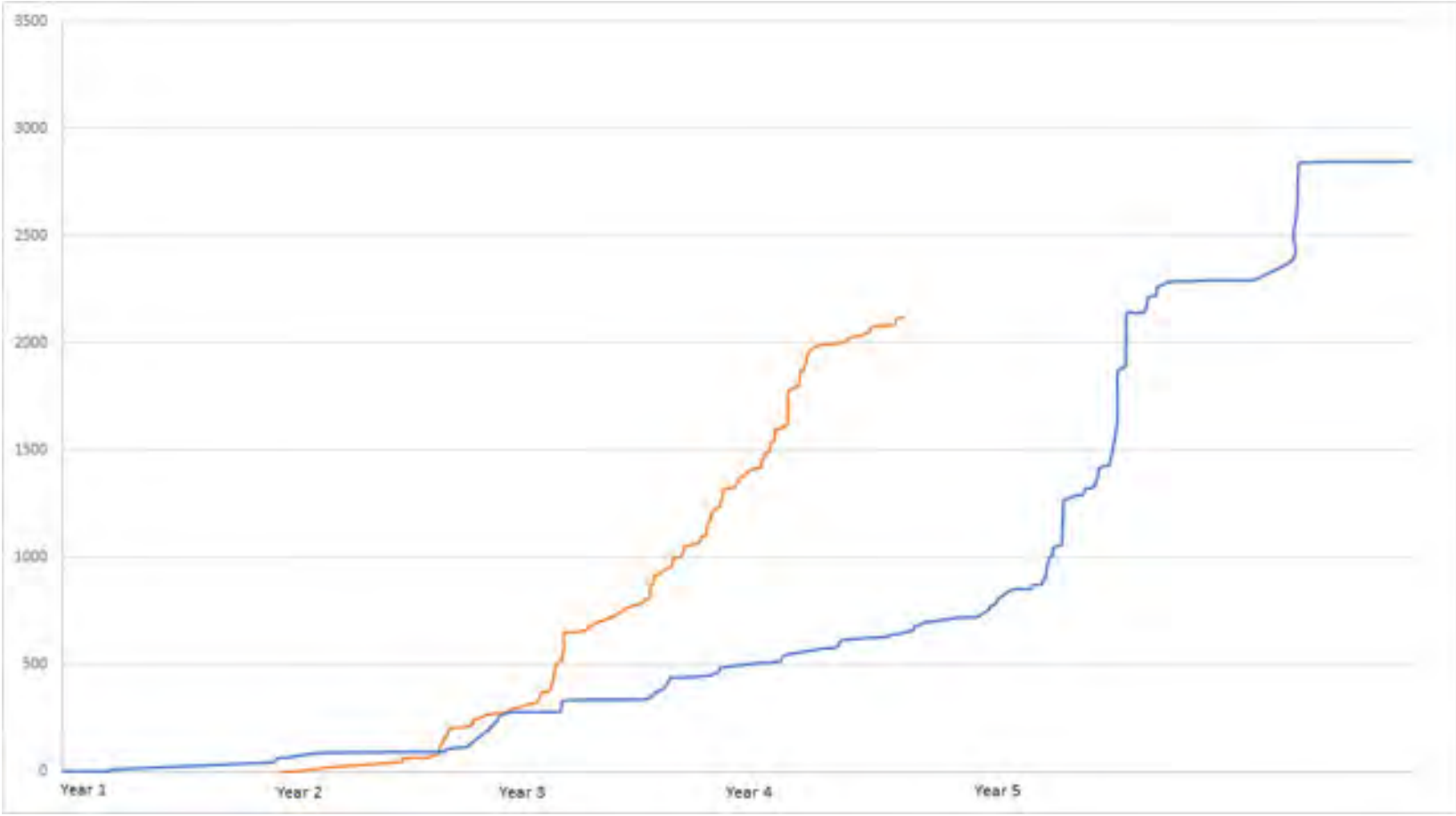


Figure 3. Total number of positives for PREDICT priority viral families in PREDICT 1 (blue line) and PREDICT 2 (orange line).

Tools in development

- **Coronaviruses**: Received samples from Bangladesh, Cambodia, Malaysia, Myanmar, Nepal, and Tanzania are preparing to ship for full-genome sequencing for PREDICT coronaviruses. These sequences will be used to understand coronavirus evolution and to develop primer sets for in-country PCR characterization of spike proteins.

- **Paramyxoviruses:** We continued development of a reverse genetics system for further characterization of paramyxoviruses to evaluate viral pathogenicity and host range. Vesticular stomatitis virus pseudotype particles have been developed that incorporate the fusion and hemagglutinin genes of a PREDICT paramyxovirus found in bats to assess cell entry and replication; sequencing of additional genomes from Cambodia, Malaysia, and Nepal is ongoing.

- **Ebola Serologic Assay:** The first shipment of human sera from eastern DRC has been tested using PREDICT ebolavirus ELISA assays. The first shipment of bat samples has also been received from Liberia for testing using these assays.

- **Refining our deep-sequencing approach:** We continued data collection and ongoing analysis to compare results of high throughput sequencing using unbiased sequencing and VircapSeq-VERT along with factors that affect sequencing success.

- **Development of ebolavirus reagents:** Antibodies against various proteins for the new Bombali virus have been produced (GP, NP, VP24, VP35). Recombinant VSV expressing the Bombali glycoprotein has also been developed.

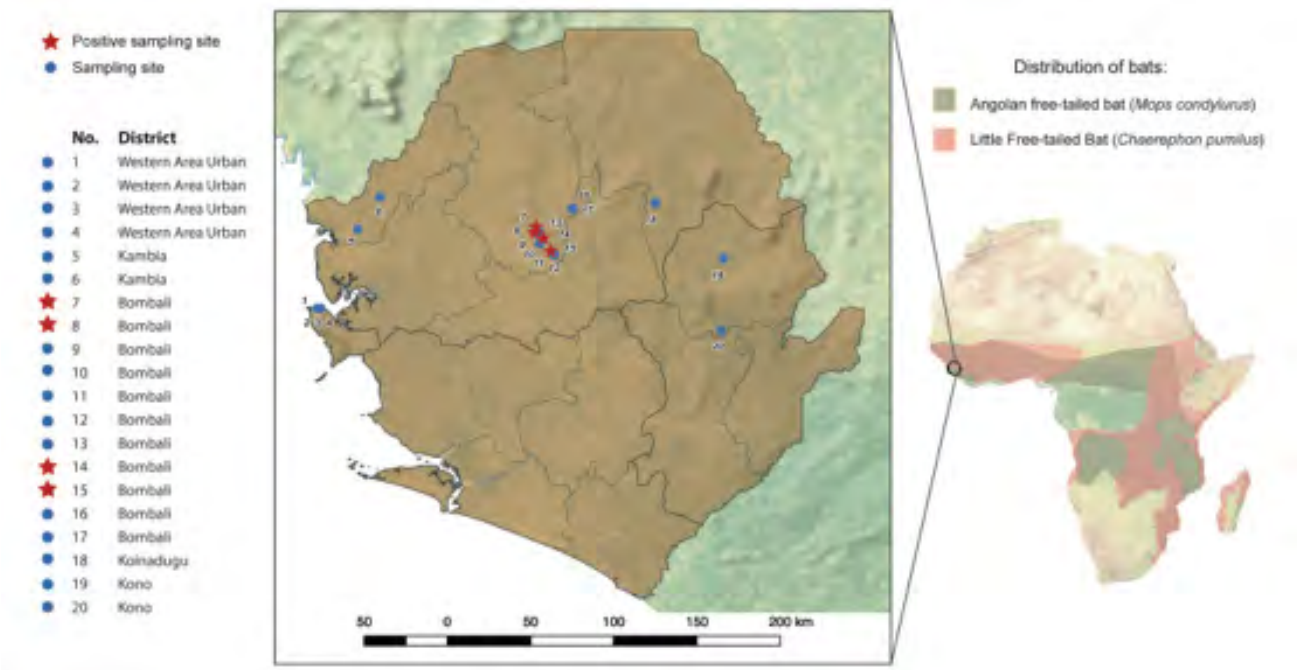
Viral Findings

A table of comprehensive viral findings approved by host government partners for public release is provided at the end of this section. All approved viral findings are also available on PREDICT's public site: www.data.predict.global.

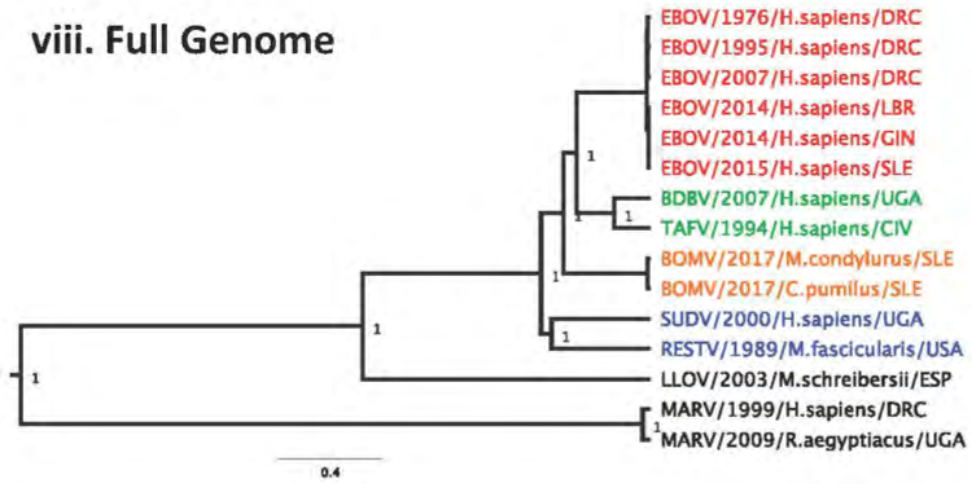
New Findings

The article **"The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses",** was published in *Nature Microbiology*, in August 2018 and is available online at: https://www.nature.com/articles/s41564-018-0227-2

Summary of findings: Here we describe the complete genome of a new ebolavirus, Bombali virus (BOMV) detected in free-tailed bats in Sierra Leone (species: *Chaerephon pumilus* and *Mops condylurus*). The bats were found roosting inside houses, indicating the potential for human transmission. We also show that the viral glycoprotein can mediate entry into human cells, though further studies are required to test whether exposure has actually occurred or if BOMV is pathogenic in humans.



Map showing the distribution of Angolan free-tailed bats (Mops condylurus) and Little free-tailed bats (Chaerephon pumilus) (based on International Union for Conservation of Nature [IUCN] data) and the animal sampling locations in Sierra Leone.



Phylogenetic tree comparing the relationship of BOMV to other known filoviruses shown here for the complete genome. Analysis shows it is new species within the Ebolavirus genus.





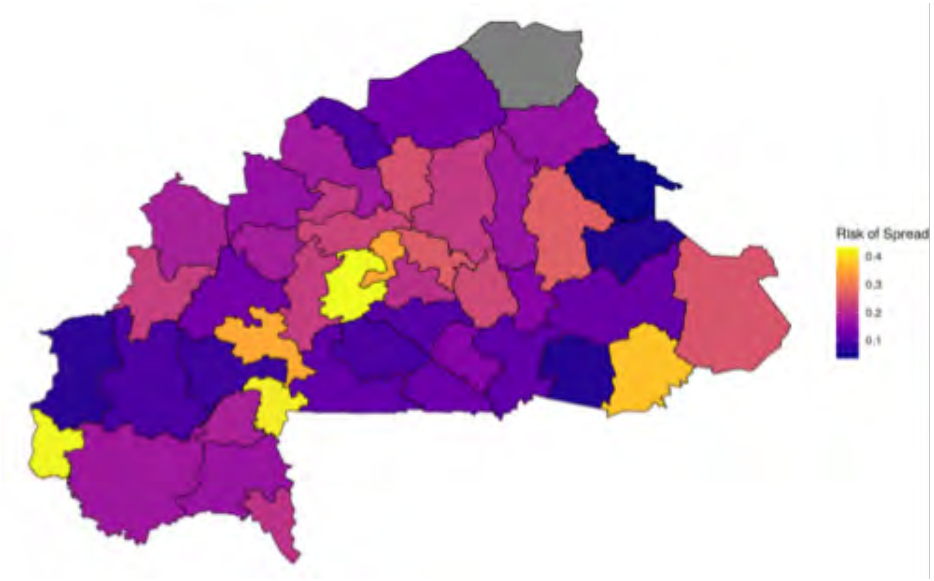


PREDICT staff and lab technicians at work in the labs. Photo credit: PREDICT

Modeling and Analytics (M&A)

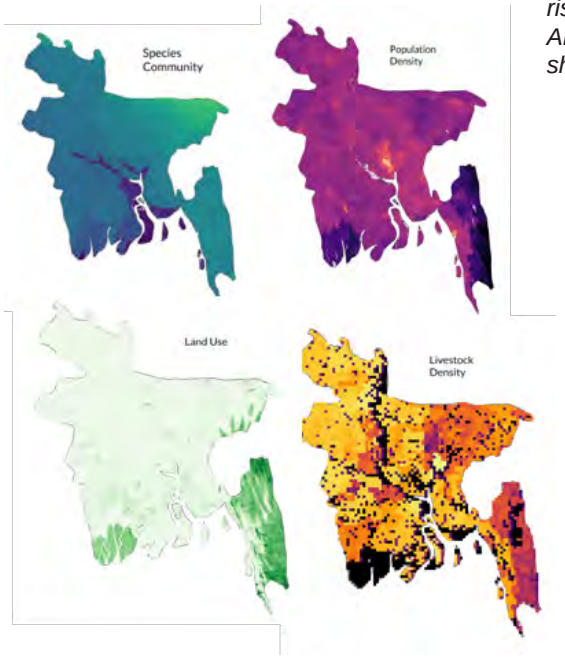
Major highlights and successes

PREDICT's M&A team continued to collaborate with FAO on the Africa Sustainable Livestock 2050 (ASL2050) project to model the risk of disease in the face of expanding livestock production in Africa. PREDICT attended a workshop in Kenya, March 26-30, 2018, to meet with FAO and other partners and present new avian influenza epidemic spread models using household and commercial poultry density data for several African countries. **New country-specific avian influenza risk models using poultry network data were developed for Burkina Faso, Uganda, Kenya, and Nigeria.** We have also downscaled the Hotspots 2.0 model for each ASL2050 country to give higher resolution maps for in-country interpretations.



Province-level avian influenza epidemic risk map for Burkina Faso.

Country-specific spatial zoonotic risk reports were presented to each of the 28 PREDICT country teams at the All-country meeting in Brussels. Each report utilized data from two recent PREDICT projects, Hotspots 2.0 (assessing zoonotic spillover risk) and the Host Pathogen Phylogeny Project (predicting the number of 'missing' or unsampled zoonoses in wild mammals). They also mapped out how key drivers vary across countries (e.g., land use and population density). These major updates to previous maps include down-scaling of the Hotspots 2.0 model to give higher resolution maps for in-country use and extrapolation of the predicted zoonotic viruses model to include all mammals, even those with no recorded viral detection in the literature. Feedback from country teams was collected and will be integrated into an updated release.



Example of country-level maps of key contributing factors to zoonotic risk presented at the PREDICT All-country Meeting. Bangladesh shown here.

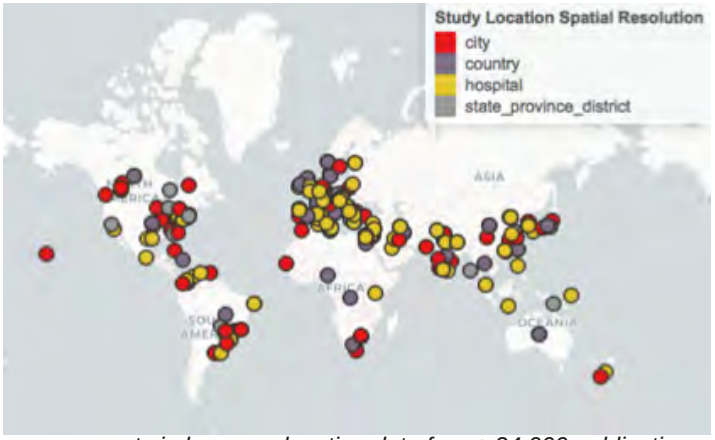
PREDICT contributed to the analysis of the Global Virome Project's (GVP) predicted viral diversity and costs of viral discovery recently published in *Science.* Using PREDICT findings, the team estimates that there are 631,000-827,000 undiscovered viruses capable of infecting humans. Building on this work, the PREDICT team has developed a spatial modeling approach to identify priority sites for optimal viral sampling in wildlife at a 10 x 10 km resolution in countries around the world. The first country with a completed, new GVP site selection analysis was Thailand, in preparation for a Thailand National Virome Project workshop held in Bangkok in October 2018, where the findings were presented to Thai government stakeholders.

PREDICT conducted training with the Indonesia One Health Network (INDOHUN) for three weeks in March 2018 to help them design an economic model of land conversion for the Riau Province, and for two weeks in September 2018 to help finalize the economic modeling. This is a collaborative EPT project between PREDICT M&A team and USAID's One Health Workforce project including INDOHUN and the University of Minnesota.

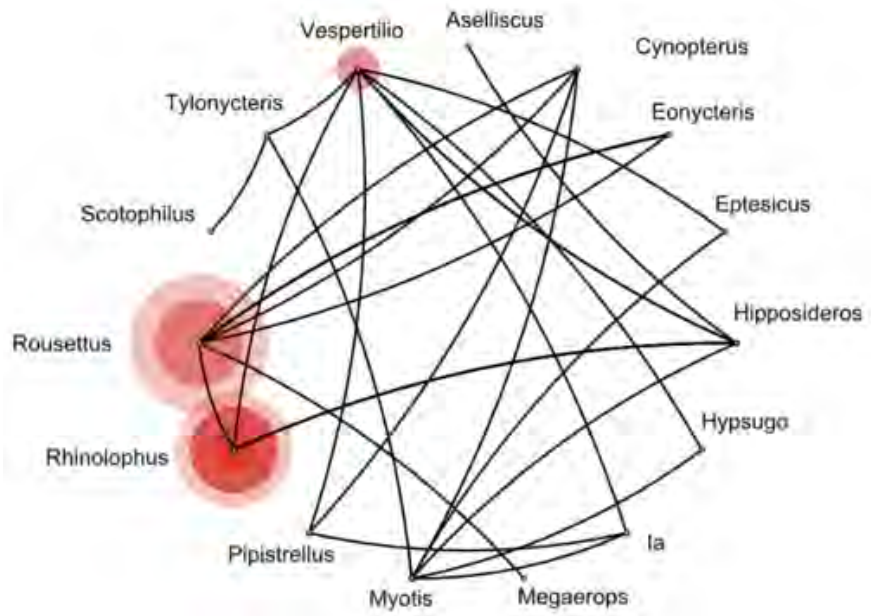
PREDICT's M&A representative collaborates with INDOHUN and University of Minnesota on the economics of land conversion in Indonesia.

Progress and new model development

PREDICT completed three rounds of scientific abstract screening and two rounds of data extraction to refine underlying data for a spatial 'hotspots' model of antimicrobial resistance emergence in humans, which will be the first of its kind. This **AMR emergence database** and analysis gives us the most comprehensive view into the distribution of species, drugs, and places where AMR emerges in people. A total of >49,000 articles have been screened to date. The project has completed the full-text review and data extraction stage for 24,000 selected articles. Additionally, we harnessed the data generated during this time- and labor-intensive manual screening process **to create a machine learning model that can pre-screen abstracts, and performs with 85% balanced accuracy**- which will allow us to automate the expansion of this database in the future.



AMR emergence events in humans, location data from >24,000 publications.



Evolutionary origins and cross-species transmission of bat coronaviruses in China. Analysis shows that three bat genera are the most important sources of strain diversity in beta-coronaviruses, the group that includes SARS and MERS coronavirus.

The spillover and spread of coronaviruses from bats to people or livestock (e.g., SARS, SADS) represents a major threat to health and food security. **To better understand the origins and cross-species transmission of coronaviruses,** we used a Bayesian analysis to reconstruct the bat hosts and locations (provinces) in China most likely to be the source of host-jumps for alpha- and betacoronaviruses using PREDICT data. We found that Vespertilionidae and Rhinolophidae bat families are the evolutionary sources of Alpha-CoVs, while Vespertilionidae and Pteropodidae are the evolutionary sources of Beta-CoVs. In the same analysis, we discovered that Southwestern and Southern China are the evolutionary hotspots of Alpha- and Beta-CoVs.

We updated the EIDITH R package in collaboration with the Information Management team to allow individuals with EIDITH database access to download their country-level PREDICT-2 data as per their permissions into the statistical analysis program, R. Site characteristics, behavioral risk, animal, or testing data can then be manipulated in R to explore and visualize data from the project in near real-time as they are entered into the database. Tutorials and examples showing how to navigate the PREDICT data are also in development.

Analyzing PREDICT data to support surveillance

We refined a model to test for seasonal patterns in bat viral shedding while accounting for other potentially important factors (e.g., age, gender, reproductive status) and controlling for methodological and technical variation within the data. This analysis uses a hierarchical Bayesian model and demonstrates the value of big datasets such as PREDICT's to the global science community to understand risk factors for spillover and periods of the greatest value for sampling wildlife to identify viruses.

Using a similar approach, we developed a model that examines the effect of reproductive status on viral detection across bats, rodents, and primates. This analysis sheds light on basic questions regarding the relationship between host life cycles and viral infection.

Communicating findings to guide interventions and target surveillance

The PREDICT M&A team produced three *Emerging Disease Insights* reports this year. These include: 1) an analysis of understudied flaviviruses that may represent a spillover threat to humans; 2) an economic justification for investment in EID prevention, such as the Global Virome Project; and 3) refined viral accumulation curve analyses of PREDICT data to identify host taxa that require further sampling. Emerging Disease are freely available online by the research community and the general public. These latest documents were also translated into French.

With the PREDICT Behavioral Risk team, members of the M&A team helped develop a prototype Behavioral Risk Characterization technical report. The team created a rapid, reproducible

PREDICT's M&A representative leads a livestock epidemic risk mapping workshop with FAO and other ASL2050 partners in Nairobi, Kenya.

behavioral risk analysis workflow that can be easily applied to data from individual PREDICT countries and design intervention strategies that target locally-relevant disease risk factors.

Analyses that inform interventions

The M&A team is supporting PREDICT's six "deep dive" areas to assess potential evidence-based risk interventions, and define the boundaries under which interventions might prove successful. In addition, great progress has been made this year by PREDICT technical teams and country staff to conduct analyses of literature and project data for 15 **IMPACT** projects (**I**ntervention **M**odeling **P**rojects **AC**ross **T**eams). These are intended to provide rapid answers to questions about the validity of proposed intervention strategies and were designed with 3-, 6-, and 12-month timelines to assure completion before the end of the project period of performance.

As part of one IMPACT project, a regional map of *Rhinopholus* bats and pig overlap was produced to help target surveillance

Areas of greatest risk for SADS-CoV spillover. Based on species distribution models for three Rhinolophus host species where probability of occurrence is high (>75%) and overlap with pig densities that are indicative of intensive pig farming (>100 heads per km2).

for mitigating future spillover events of the new Severe Acute Diarrheal Syndrome Coronavirus (SADS-CoV), recently discovered to have emerged from bats to swine.

Other IMPACT projects in progress examine:

- the risk of viral spillover from bats to hunters
- bat tourism
- guano harvesting
- quantifying risk in wildlife animal markets

The six deep dive areas of the IMPACT projects.

In the coming year, the M&A team will coordinate collaboration across PREDICT, EPT, and our in-country teams in modeling, capacity-building, and scientific communication efforts as part of these projects.

For more information

A full list of PREDICT M&A team products and outputs are included in the *Monitoring and Evaluation Appendix 1*. Emerging Disease Insights are available online: http://livescience.ecohealthalliance.org

One Health Partnerships

One Health policy advocacy

PREDICT-2 collaborated on the development of the World Bank's Operational Framework for Strengthening Human, Animal and Environmental Public Health Systems at their Interface ("One Health Operational Framework"). The Framework features extensive lessons learned through PREDICT-2 and its partners, including One Health success stories and operational guidance across the prevent-detect-respond-recover spectrum, including at country level and in project design. Building on our work with the World Bank on One Health Economics, it details the value of investing in One Health and showcases how to identify relevant entry points and measure outcomes. It also suggests One Health-relevant Environment and Social Safeguards to help avoid unintended disease risks from development activities.

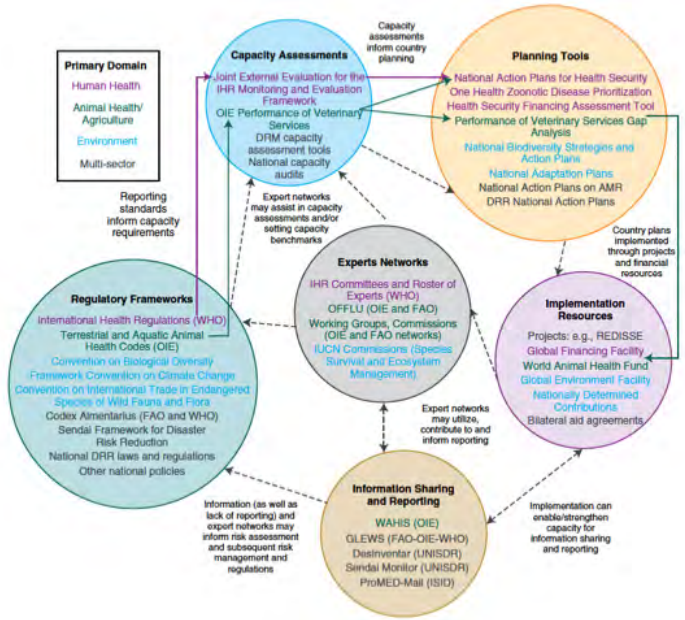


Figure 1: The One Health Operational Framework provides a 'map' of tools from different sectors to support One Health coordination.

To reinforce the importance of coordination of national capacity assessments and planning across sectors for health security, PREDICT coordinated a session on "Operationalizing One Health: from Assessment to Action" in partnership with USAID, P&R and the World Bank at the Prince Mahidol Award Conference (PMAC) in Bangkok. The session launched the One Health Operational Framework and featured presentations on relevant tools, synergies and experiences from FAO, OIE, OHW, U.S. CDC, WHO, Toward a Safer World Network, and country leaders in One Health.

Key Areas of Policy Engagement: Translating Best Practices for One Health Action

UN/ IGO/ MDB

CITES

Convention on Biological Diversity

Food and Agriculture Organization of the United Nations

Global Health Security Agenda

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

UNISDR
United Nations Office for Disaster Risk Reduction

World Health Organization

OIE

In collaboration with USAID RDMA, we also convened a panel at PMAC on harnessing the economic dimensions of health security, including incentives to address the drivers of emerging infectious disease and AMR. An accompanying piece in the WHO Bulletin presents pillars for investments in EID prevention.

To assist countries in determining where One Health approaches can be most beneficial for their operations, we developed a "Quick Guide to One Health Evaluation". The guide helps orient users to evaluation processes and identify relevant metrics to inform decisions, including budget allocation across sectors.

Quick Guide to One Health Evaluation

One Health is an interdisciplinary collaborative effort to attain optimal health for people, animals and the environment we depend on.

The One Health concept has received growing attention around the world as a way to help address challenges at the human-animal-environment interface—such as emerging and endemic zoonotic diseases (e.g. Ebola, Avian Influenza, Rabies), antimicrobial resistance, and food safety and security. With ecosystems and food production systems rapidly changing as a result of human resource demands, it is critical to understand the connections between humans, animals and the environment to find effective solutions that promote local and global health security and resilience.

To help move from broad interest to operational aspects of One Health on the ground, policy makers and donors have called for *an evidence base for One Health*, particularly in terms of its potential to assist public health systems in shifting from resource-intensive response to disease events to prevention, early warning, and enhanced detection of public health threats. As with evaluation for any program, evaluating One Health approaches can help refine implementation strategies for optimal outcomes and inform ways to adapt and upscale approaches in other settings, countries, and priority topics.

What should I evaluate?

Given the many topics that a One Health approach may assist with, a wide range of effectiveness and efficiency metrics (such as disease incidence, economic outcomes, years of life saved, number of people trained, etc.) could potentially be meaningful. Key factors to consider include:

- What is the scope of my particular topic and objective? Is it global, national or local?
- Who is my audience? What outcomes are relevant to them?
- What process(es) do I want to inform?
- What information is readily available?

This quick guide is intended to assist governments, research and service delivery projects, and donors to get started in thinking about opportunities to measure One Health's added value for decision-making. Models projecting outcomes under different scenarios can be useful and to date make up a large portion of One Health studies. However, results from implementation can help demonstrate feasibility and success in real-life and local contexts. The following pages provide insight on these and other criteria and introduce guidance for conducting evaluations. In general, the best approach is to choose an outcome that is relevant, understandable, and actionable for your audience.

? *What about other terms -- Planetary Health, Eco-Health, or Veterinary Public Health? Like One Health, they all represent integrated approaches. Consider this a guide for all of them -- regardless of the name, the goal is to improve outcomes for humans, animals and the environment.*

Other highlights and success stories

PREDICT-2 also served on the Scientific Committee for the 2nd OIE Global Conference on Biological Threat Reduction, organizing a session on the future of biological threat reduction. In light of gaps in risk reduction efforts around environmental drivers of zoonotic disease. PREDICT-2 worked to provide key input into the development of the World Bank's Country Assessment for Environmental Health Services, including capacities for wildlife disease monitoring and risk management. The draft capacity assessment tool, which is envisioned as a parallel to the WHO joint External Evaluation and OIE Performance of Veterinary Services evaluation, was introduced at the UN Convention on Biological Diversity (CBD) meeting in December 2017 in collaboration with the World Bank and the CBD Secretariat.

In recognition of strong country interest in PREDICT's approach to multisectoral economic evaluation of zoonotic disease, we presented on One Health Economics in a symposium at a conference organized by the Bangladesh Society for Veterinary Education and Research. The presentation was part of a symposium on the 'Economic Impact of Prioritized Zoonotic Diseases' and included representatives from the ministries of wildlife, livestock and disease control, and FAO.

PREDICT supported the development of the FAO/OIE/WHO Tripartite Zoonoses Guide on "Taking One Health Approaches to Address Zoonotic Diseases in Countries", co-authoring chapters on risk reduction and planning and preparedness and attending the expert meeting held in February 2018. In response to requests from country representatives on the need to make the case for One Health's utility, we also developed a section on financing and economic value added from One Health approaches to zoonotic disease prevention and control. PREDICT also provided input on the development of WHO's guide for multisectoral partnership coordination, helping to broaden the scope of preparedness efforts and consider the role of non-state actors to support prevention strategies upstream of disease emergencies.

Given the importance of efficient investigation of major emerging infectious disease events for health security, PREDICT liaised with international animal trade organizations to address permitting delays that have hindered investigation of recent wildlife mass mortality events. Our team was appointed to serve on a working group on simplified procedures to promote timely movement of emergency diagnostic specimens convened by countries under the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES). The working group issued formal recommendations, including permit exemptions for disease emergencies through the use of reference laboratory networks, that will advance to the CITES Conference of the Parties for approval.

In continuation of our collaboration with WHO on the environmental dimensions of health security, we coordinated a presentation from PREDICT partner, the Ghana Forestry Commission, for WHO's Stakeholder Consultation on National Health Security and Pandemic Influenza Preparedness Planning held in Accra in December 2017. The presentation featured approaches for pathogen surveillance in wildlife.

The American Public Health Association adopted its first-ever policy statement on One Health at its Annual Meeting in November 2017. PREDICT developed the policy, which provides concrete action steps for the public health community to advance health security and pandemic prevention and preparedness capacity in the U.S. and globally. Finally, to help shape the direction of the Global Health Security Agenda 2024, PREDICT provided input on the draft framework to promote a multisectoral scope, including involvement of the environment sector.

New publications, products, and policy briefs

Key outputs from this year emphasized the economic benefits of reducing emerging disease risks and included:

- "A framework for stimulating economic investments to prevent emerging diseases" in the *Bulletin of the WHO*, calling attention to risk reduction to yield global public good through improved health security.
- "Investing in One Health" policy brief, accompanying the World Bank One Health Operational Framework.
- "One Health Economics to Confront Disease Threats" in *Transactions of the Royal Society for Hygiene and Tropical Medicine*, disseminating key messages from a 2017 workshop held at the World Bank.
- "Emerging infectious disease risk: shared drivers with environmental change" and "Biosurveillance: a systematic review of global infectious disease surveillance systems from 1900 to 2016", both in the *OIE Scientific and Technical Review* edition on biothreat reduction, disseminating under-utilized and high-potential approaches for prevention and detection of EIDs.

Selected presentations on PREDICT, One Health, zoonotic diseases, and global health security

- Presented on PREDICT-2 One Health evaluation activities at the Chatham House meeting on "One Health: Developing Indicators to Monitor Progress Toward Implementation".
- Chaired the OIE Working Group on Wildlife Meeting and presented outcomes at the OIE 86th General Session, highlighting new and emerging wildlife disease events and reinforcing the importance of country reporting for wildlife diseases to OIE delegates.
- Presented on disease risks at the human-animal-environment interface in a PMAC panel on "Strategic Information and the Evolution of Emerging Infectious Diseases: Lessons from the Past and New Opportunities" organized by UNAIDS and U.S. CDC.
- Presented at high-level GHSAC event held at the US State Department.
- Shared approaches to target disease emergence risk and operationalize One Health for the monthly meeting of the U.S. interagency Pandemic Prediction and Forecasting Science and Technology working group, a group that reports to the National Science and Technology Council.

- Presented on PREDICT approaches, including the role of wildlife health monitoring in global health security, at multiple side events at the Convention on Biological Biodiversity (CBD) 21st meeting of the Subsidiary Body on Scientific, technical and Technological Advice; PREDICT helped inform the Guidance on integrating biodiversity considerations into One Health approaches released by the CBD Secretariat.
- Presented on risk reduction strategies on a Future Earth webinar with World Bank, CBD and UNISDR colleagues. Served as keynote speaker on “One Health as a Pillar of Policies” at the International One Health Congress, highlighting opportunities for multisectoral coordination to advance health security.
- Presented on the role of human, animal and environmental health capacity strengthening in health security at Liberia’s second One Health Coordinating Platform meeting chaired by the country’s Vice President (non-PREDICT activity).
- Participated in a meeting of the French national research network on human health (INSERM) on global viral diversity monitoring, and coordinated a meeting on biodefense with the French Prime Minister’s office.

Management & Operations

Highlights & successes

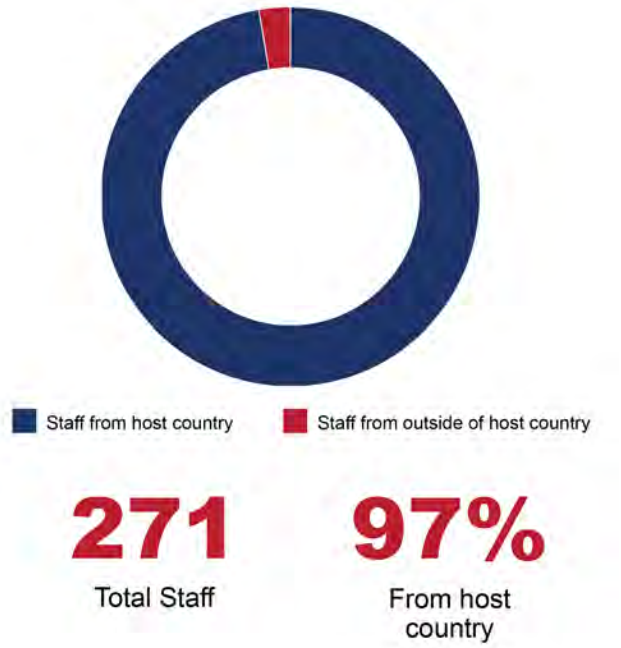
The PREDICT Consortium held our second All-Country meeting January 9-11, 2018 in Brussels, Belgium. The meeting, which featured guests from the European Union and EPT-2 partners from the Food and Agriculture Organization of the United Nations, included participants from all 30 PREDICT countries and provided a forum for evaluating our progress to date and for developing strategic plans for remaining activities. Through data-driven workshops on risk characterization, panel discussions exploring PREDICT's One Health approach in action, and discussions and consultations with USAID and the project's external advisory board, we built a strong foundation for tackling remaining tasks. Additionally, PREDICT hosted a poster competition, with participation from all 28 actively engaged One Health country teams, which encouraged dialogue and fostered a sense of community as peers worked together to review posters and award honors.

> ***"I think this type of meeting is essential for disseminating information broadly, guiding project deliverables and troubleshooting potential problems. Not to mention helping with collegiality for what is already a highly collaborative project."***
>
> -A participant at the PREDICT All-country meeting in Brussels, Belgium

On January 29, 2018, during the Prince Mahidol Award Conference (PMAC) in Bangkok, Thailand, PREDICT and the Global Virome Project (GVP) planned and successfully hosted a meeting entitled "Introducing the Global Virome Project". This was the second global in-person meeting following the Beijing meeting in February 2017. In Bangkok, participants, including members of the GVP Steering Committee, Working Group members, country collaborators in China and Thailand, as well as PREDICT and EPT-2 partners worked together to discuss ways to implement evolving strategies and plans. Additionally, the project was introduced to the international public health community, various government officials, and key stakeholders. For more info on GVP visit: **http://www.globalviromeproject.org/**

Personnel

We continued to manage and coordinate an international consortium of partners consisting of over 271 in-country staff, 97% from the host countries where they work.



Partnerships

Continuing to build and formalize One Health partnerships, we executed 22 subaward agreements since the start of the project, 90% of the agreements with foreign government entities and laboratories in Asia and Africa, enabling PREDICT to further advance capabilities for zoonotic disease surveillance, detection, and response.

Permissions

PREDICT continued working with global and international partners to ensure compliance with all international and host country laws, regulations, and policies, including Memoranda of Understanding and Letters of Agreement, permissions for conducting research and collecting samples, import and export permissions, biosafety certificates, and ethical clearance for conduct of One Health surveillance (institutional review boards and animal care and use committees).

Communications

PREDICT continued outreach and communication efforts at the global and host country levels, producing briefings, reports, and online communications and establishing social media channels on ResearchGate for scientific publications and presentations and Twitter (**@PREDICTproject**) for general outreach and information. In addition, PREDICT continued our commitment to open data, making host county government approved findings available online through the PREDICT BioProject on GenBank and through our HealthMap hosted data portal at **www.data.predict.global**

PHOTOS ((clockwise from top-left):): PREDICT/Nepal team at PREDICT All-Country Global Meeting in Brussels, Belgium; Andrew Clements at the 2018 All-Country Meeting; David Wolking preparing for in-country team operations; PREDICT UC Davis Global Operations team.

Photo: D. McIver, PREDICT/Lao

IV. COUNTRY REPORTS

DASHBOARD KEY

USAID | PREDICT
FROM THE AMERICAN PEOPLE

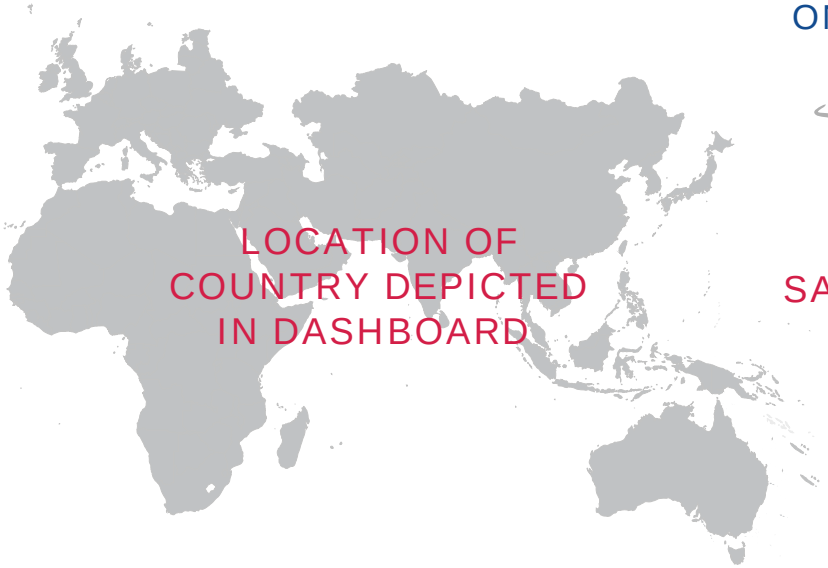
Global Health Security Agenda

WORKFORCE DEVELOPMENT

STAFF STUDENT GOVERNMENT OTHER

TRAINING #'S INCLUDE PROJECT STAFF AND OTHER STAKEHOLDERS

MALE FEMALE



ONE HEALTH SURVEILLANCE

ANIMALS & PEOPLE SAMPLED OR INTERVIEWED

LAB STRENGTHENING

OF TESTS USING P2 VIRAL FAMILY DETECTION PROTOCOLS, COLOR INDICATES LAB CAPACITY STATUS ACCORDING TO KEY BELOW

NAME OF LABORATORY INSTITUTE

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT LEGEND

 # people trained in One Health skills
 # individuals sampled
 # individuals interviewed in behavioral risk investigations
# of laboratory tests
# of unique viruses detected

VIRUES DETECTED

#'S OF VIRAL **DETECTIONS** APPROVED BY HOST COUNTRY GOVERNMENT PARTNERS FOR PUBLIC RELEASE INCLUDES PREDICT-1

VIRUSES FOR CONTINUING COUNTRIES

www.predict.global

PREDICT-2

PHOTOS (clockwise from top-left): Senegal team at PREDICT Global Meeting; Lab technicians in Senegal; Rhesus macaque in Nepal; Sierra Leone field team; Community engagement in Guinea; Field team in Myanmar.

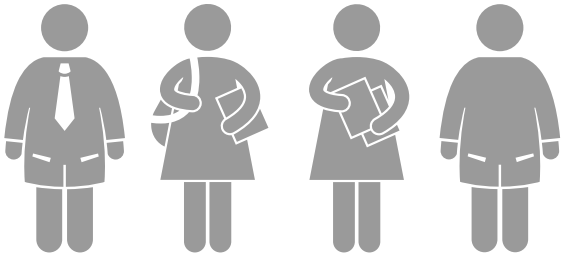
CAMEROON

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

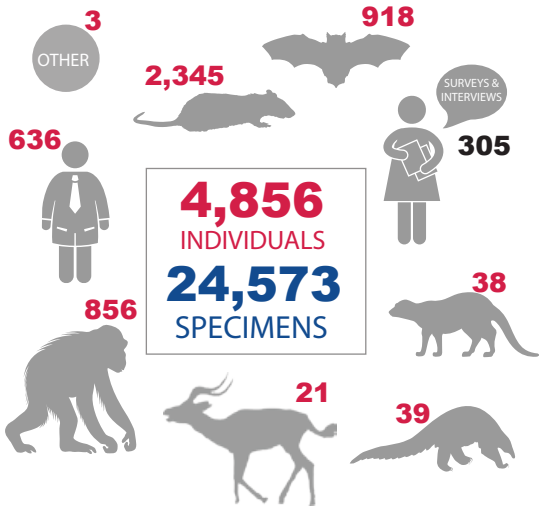
WORKFORCE DEVELOPMENT

41	38	41	100
STAFF	STUDENT	GOVERNMENT	OTHER



134 MALE | 81 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

52,303 TESTS

CENTRE FOR ARMY HEALTH RESEARCH (CRESAR)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

215 trained in One Health skills

4,856 individuals sampled (animals and humans)

941 individuals interviewed in behavioral risk investigations

52,303 tests for 5 viral families

20 unique viruses detected

www.predict.global

VIRUSES DETECTED

PREDICT-1		PREDICT-2	
91 NEW VIRUSES		**11** NEW VIRUSES	
		5 PREDICT-1 VIRUSES	
15 KNOWN VIRUSES		**4** KNOWN VIRUSES	

FACES OF PREDICT

EDMOND NDENGA MIKENG

PREDICT/Cameroon Water & Forest Engineer & One Health Focal Point
Ministry of Forestry & Wildlife,
Directorate of Wildlife & Protected Areas

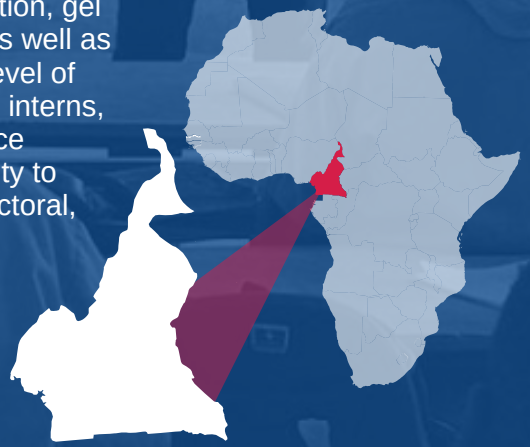
With his appointment as the Ministry of Forestry and Wildlife (MINFOF) One Health Focal Point, Mr. Ndenga's role expanded to address issues of wildlife disease and zoonoses for Cameroon's Directorate of Wildlife and Protected Areas. As such, he was selected to join the PREDICT/Cameroon team to gain important practical experience in zoonotic disease surveillance. Mr. Ndenga completed PREDICT training modules and joined several PREDICT wildlife surveillance missions to sites in the Southern Region of Cameroon where he assisted in the collection, packaging, storage, and transport of specimens. Through this experience, Mr. Ndenga gained valuable insights regarding high-risk human-wildlife interfaces in Cameroon, the importance and proper use of personal protective equipment, how to safely capture bats using mist nets, and rodents with live traps, to collect oral, rectal, and blood samples, and how to maintain cold chain, and securely transport samples to the laboratory for analysis. Following his on-the-job training for zoonotic disease surveillance during PREDICT field activities, Mr. Ndenga joined the PREDICT team to train game rangers from nine protected areas around Cameroon.

***

CYBELLE MEZAJOU FODIEU

PREDICT/Cameroon Laboratory Intern
Centre for Research & Military Health
& Catholic University of Central Africa

Cybelle Mezajou holds a bachelor's degree in biochemistry and is set to graduate in December 2018 with her Master s degree in bacteriology and virology from the Catholic University of Central Africa in Cameroon. Through a PREDICT laboratory internship at the Centre for Research and Military Health (CRESAR), Ms. Mezajou was given the opportunity to gain practical knowledge and skills that will serve her as she advances in her career as a molecular virologist, and consequently enhance national workforce capacity for viral detection and laboratory management. Her internship included learning PREDICT protocols for nucleic acid extraction, synthesis of cDNA from RNA extracts,conventional PCR, gel preparation, gel electrophoresis,product purification and cloning, as well as laboratory management skills to maintain a high level of biosafety, biosecurity, and organization. PREDICT interns, like Cybelle Mezajou, receive invaluable experience working in a national laboratory, and the opportunity to learn and network amidst a collaborative, multi-sectoral, trans-disciplinary team, putting the One Health approach into practice.



CAMEROON

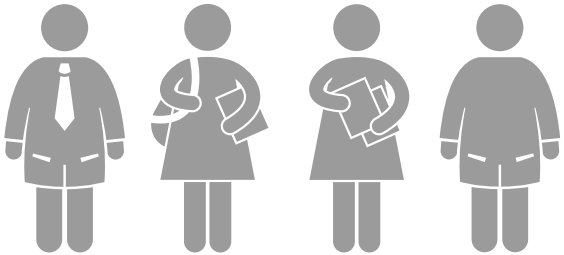
COTE D'IVOIRE

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

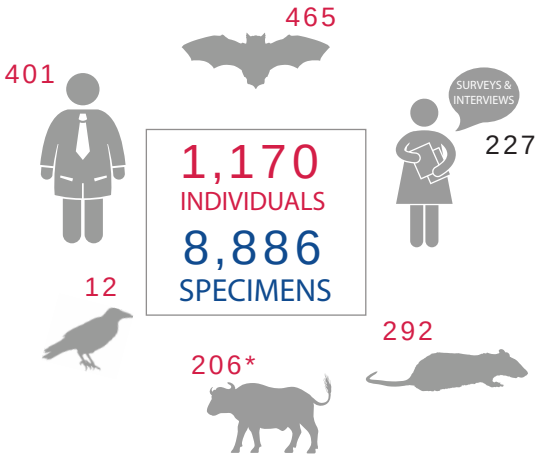
WORKFORCE DEVELOPMENT

30	3	31	153
STAFF	STUDENT	GOVERNMENT	OTHER



146 MALE | 50 FEMALE

ONE HEALTH SURVEILLANCE



*Samples collected in collaboration with FAO

LAB STRENGTHENING

36 TESTS — INSTITUT PASTEUR DU COTE D'IVOIRE

4,088 TESTS — CENTRAL LABORATORY FOR ANIMAL DISEASES (LANADA)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

196 trained in One Health skills

1,170 individuals sampled (animals and humans)

628 individuals interviewed in behavioral risk investigations

4,124 tests for 5 viral families

www.predict.global

PREDICT-2/CIV conducts rodent sampling during wildlife surveillance efforts at concurrent site in Sergeant Konakro.
Credit: PREDICT/Cote d'Ivoire

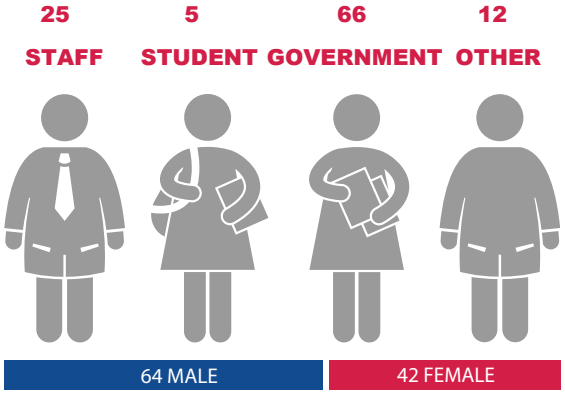
Photo: PREDICT/Cote d'Ivoire

DEMOCRATIC REPUBLIC OF THE CONGO

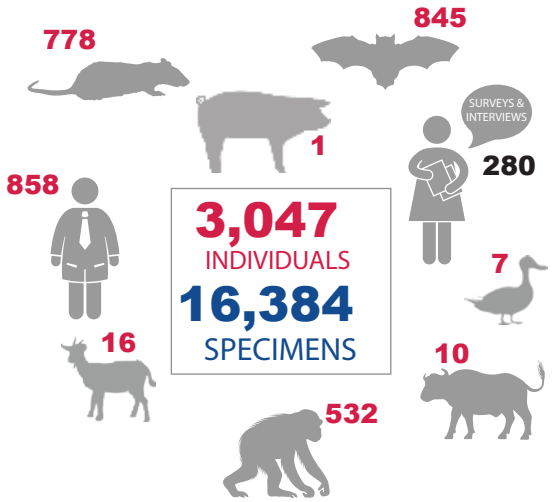
USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

24,240
TESTS

INSTITUT NATIONAL RECHERCHE BIOMEDICALE

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

106 trained in One Health skills

3,047 individuals sampled
(858 humans and 2,189 animals)

1,138 individuals interviewed in behavioral risk investigations

24,240 tests for 5 viral families

5 unique viruses detected

www.predict.global

VIRUSES DETECTED

6
NEW VIRUSES

10
KNOWN VIRUSES

PREDICT-1

5
KNOWN VIRUSES

PREDICT-2

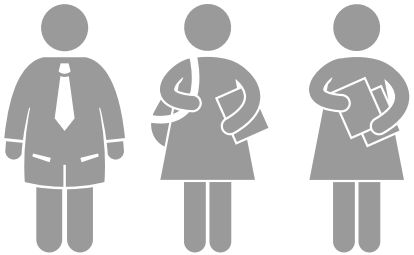
EGYPT

USAID | PREDICT

FROM THE AMERICAN PEOPLE

WORKFORCE DEVELOPMENT

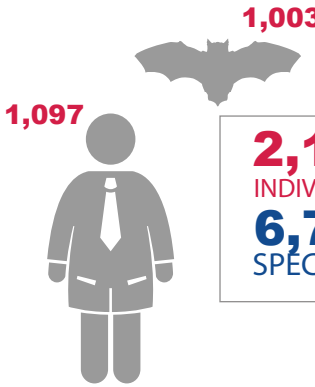
13 STAFF | 9 STUDENT | 18* GOVERNMENT



9 MALE | 9 FEMALE

*Trained staff are government employees

ONE HEALTH SURVEILLANCE



2,100 INDIVIDUALS

6,719 SPECIMENS

LAB STRENGTHENING

8,414 TESTS

CENTER OF SCIENTIFIC EXCELLENCE FOR INFLUENZA VIRUSES

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

18 trained in One Health skills

2,100 individuals sampled
(1097 humans and 1003 animals)

1,097 individuals interviewed

8,414 tests for 3 viral families

9 unique viruses detected

VIRUSES DETECTED

6
NEW VIRUSES

3
KNOWN VIRUSES

www.predict.global

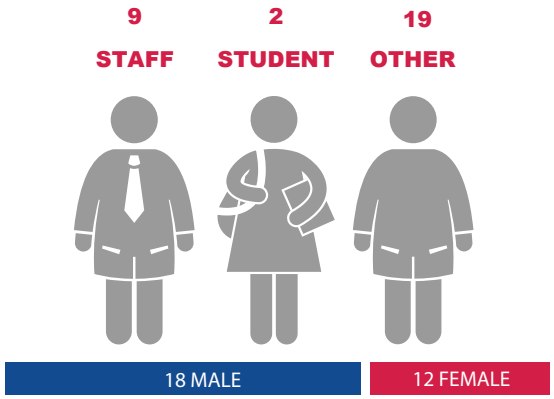
PREDICT-2

ETHIOPIA

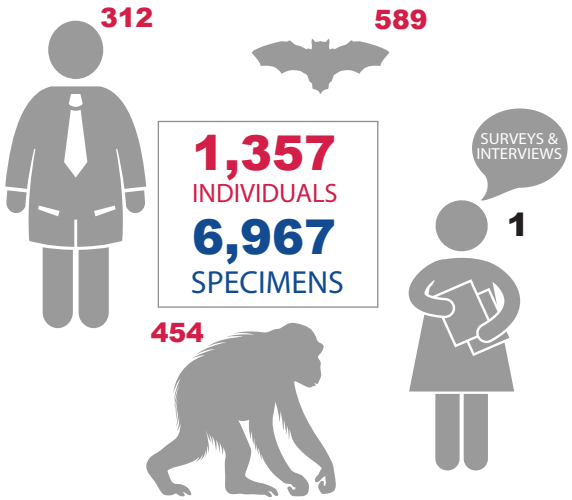
USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

558
TESTS

ADDIS ABABA UNIVERSITY
AKLILU LEMMA INSTITUTE OF PATHOBIOLOGY

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

30 trained in One Health skills

1,357 individuals sampled
(animals and humans)

313 individuals interviewed

558 tests for 5 viral families

A vervet monkey chews on an oral swab that will tested for viruses by the PREDICT/Ethiopia team.
Photo: PREDICT/Ethiopia

www.predict.global

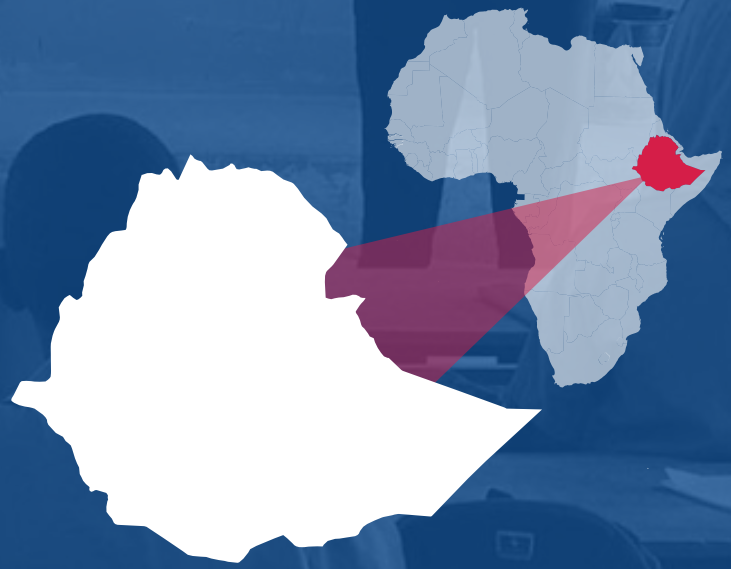
YOHANNES NEGASH GUDISA

PREDICT/Ethiopia Lead Laboratory Technician
Addis Ababa University

Yohannes Negash Gudisa, from Addis Ababa, Region 14, is the lead laboratory technician for the PREDICT project, based at Addis Ababa University. He has his Master s degree in tropical and infectious diseases and of all the animals he has worked with in field and lab-basedprojects, his favorite animal is a dog.

“My favorite part of working with PREDICT is linking with different researchers across Africa and also other continents. The project focuses on capacity building, and is committed to giving trainings before doing any field and lab activities.

I also appreciate the well-organized data managing system, EIDITH. Additionally, I’ve been able to use my skills in laboratory equipment, computer maintenance, photography, and GIS software as part of my position with PREDICT. I am actively involved with both field and lab activities. I had a big role in establishment of the new PREDICT laboratory at AAU. I am lucky and very happy to be working with PREDICT family!“



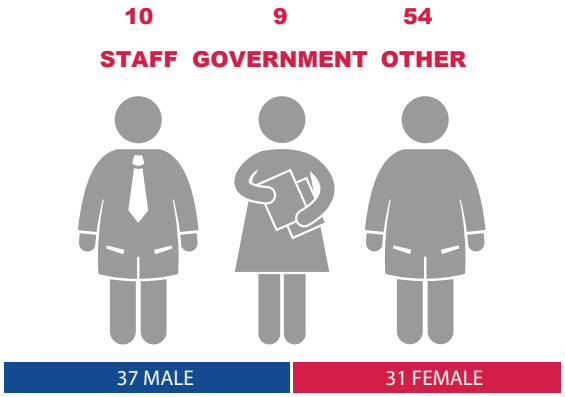
ETHIOPIA

GHANA

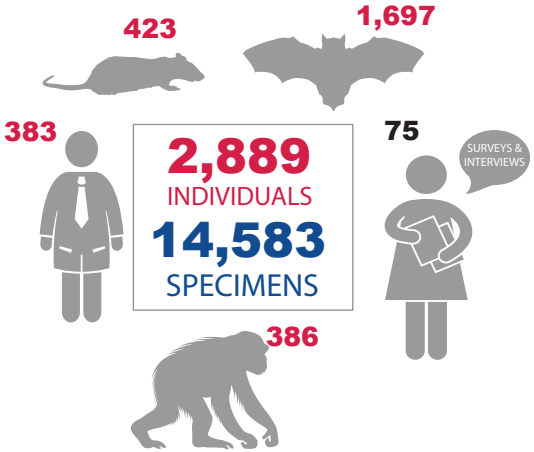
USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

360 TESTS

ACCRA VETERINARY LABORATORY

972 TESTS

NOGUCHI MEMORIAL INSTITUTE FOR MEDICAL RESEARCH

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

68 trained in One Health skills

2,889 individuals sampled

458 individuals interviewed in behavioral risk investigations

1,332 tests for 4 viral families

www.predict.global

PREDICT/Ghana conducts community engagement before a concurrent disease surveillance event at the Boabeng-Fiema site.
Photo: PREDICT/Ghana

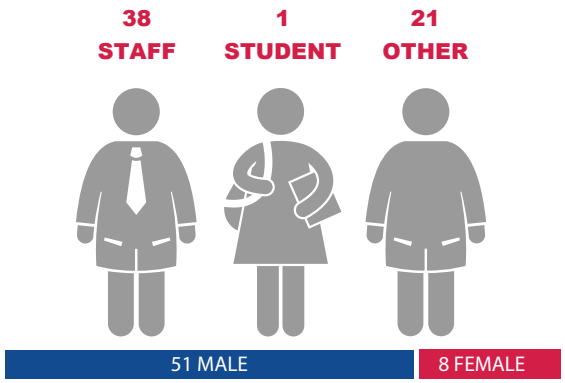
Photo: PREDICT/Ghana

GUINEA

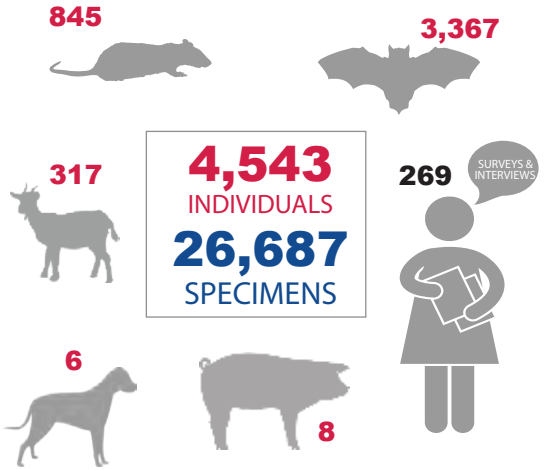
USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

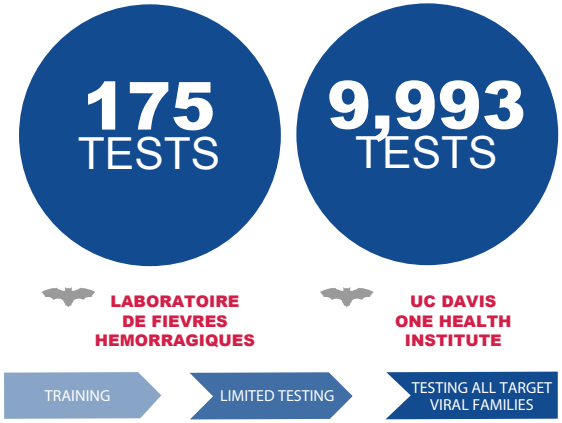
WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING



*As part of the Ebola Host Project, samples are being tested at UC Davis to accelerate release of viral findings for use for decision-making and risk mitigation efforts.

59 trained in One Health skills

4,382 animals sampled

269 individuals interviewed

10,168 tests for Ebola and other filoviruses

www.predict.global

Field technician safely sampling bats in N'zerekore, Guinea.
Photo PREDICT/ Guinea

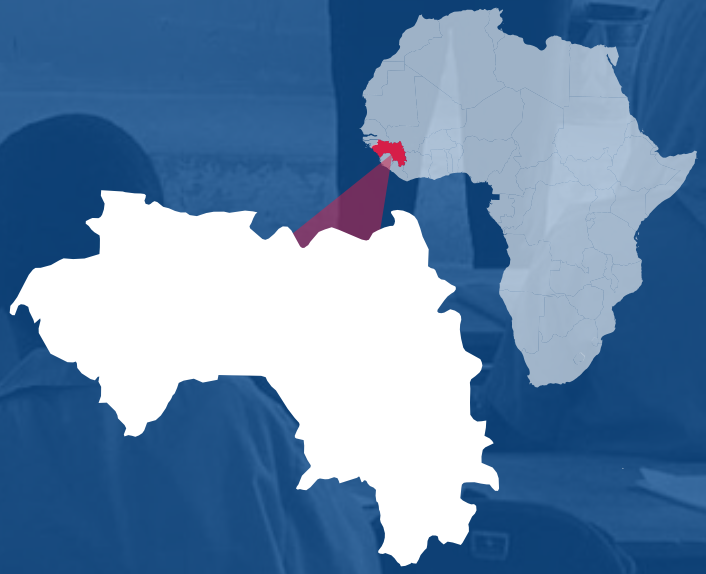
KOROPOGUI MICHEL

PREDICT/Guinea Laboratory Technician
Viral Hemorrhagic Fever Laboratory

Koropogui Michel who studied at the Universite Juluis N'Yerere de Kankan, is a lab technical at the Viral Hemorrhagic Fever lab in Conarkry. Koropogui trained with the PREDICT team and learned advanced methods for detection of both known and emerging viral threats, along with strengthening skills in biosafety and lab and data management. He is one of the scientists and health professionals excited to tackle the challenge of emerging viral threats in his country and the greater West Africa region.

"I attended all laboratory trainings offered by PREDICT as part of the institutional capacity building of Guinea's laboratory system. The trainings were very interesting and the trainer's level was very good. They allowed me to acquire new skills and perfect my good lab practices. I also learned how to do basic analyses of the PCR.

I wish that PREDICT continues to give these trainings because they gave me confidence in myself and in the future, but also they managed to give me the desire to learn and go far in the research in Virology!"



GUINEA

FACES OF PREDICT

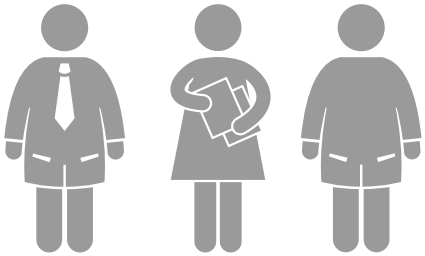
JORDAN

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

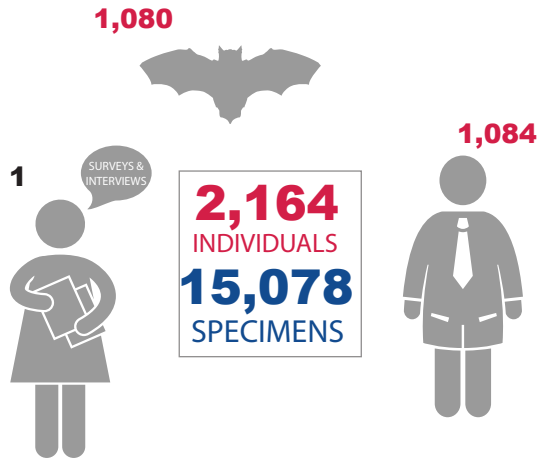
WORKFORCE DEVELOPMENT

12	2	11
STAFF	GOVERNMENT	OTHER



18 MALE | 7 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

10,255
TESTS

JORDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (JUST)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

25 trained in One Health skills
2,164 individuals sampled
1,085 individuals interviewed
10,255 tests for 4 viral families
7 unique viruses detected

www.predict.global

VIRUSES DETECTED

1
NEW VIRUSES

1
PREDICT-1 VIRUSES

5
KNOWN VIRUSES

PREDICT-2

Photo: PREDICT/Jordan

KENYA

USAID | PREDICT
FROM THE AMERICAN PEOPLE

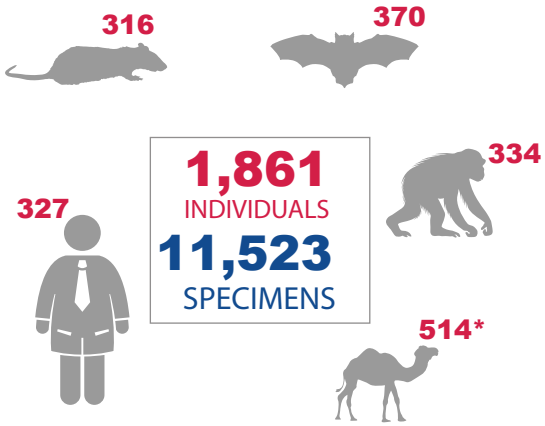
Global Health Security Agenda

WORKFORCE DEVELOPMENT

4	10	22	347
STAFF	STUDENT	GOVERNMENT	OTHER

223 MALE | 159 FEMALE

ONE HEALTH SURVEILLANCE



*Samples collected in collaboration with FAO

LAB STRENGTHENING

612 TESTS

KENYA MEDICAL RESEARCH INSTITUTE

3,580 TESTS

INSTITUTE OF PRIMATE RESEARCH

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

IMPACT

382 trained in One Health skills

1,861 individuals sampled (humans and animals)

327 individuals interviewed

4,192 tests for 4 viral families

www.predict.global

PREDICT/Kenya wildlife surveillance team collects an oral swab from a rodent while members of the Turkana community look on with interest.
Photo: PREDICT/Kenya

WINOLD MBINDYO

PREDICT/Kenya Graduate Student Researcher
LOCATION: University of Nairobi, Kenya

PREDICT/Kenya provides opportunities for postgraduate student researchers to learn techniques and gain skills necessary for biosurveillance and response to disease outbreaks. Currently the team has one PhD student and two Master s of Science students attached to the project to carry out their post-graduate research. One MSc student, Mr. Winold Mbindyo, is working on a “One health approach in understanding influenza virus infection transmission.” His experience with PREDICT armed him with knowledge of influenza viruses and disease transmission at high-risk human-livestock-wildlife interfaces, which he presented at PREDICT’s implementing partner’s (Institute of Primate Research) seminar series. After the presentation, Mr. Winold was offered a six-month internship opportunity with WHO Global Influenza Program, one clear case for PREDICT training and experience can propel students towards careers in global health.

“By joining (the) PREDICT program, PREDICT has given me an opportunity to understand factors that drive disease emergence or reemergence. I have gained advance knowledge on ‘One Health’ as (a) tool to fight outbreaks, epidemics or pandemics. This has enabled me (to) think in an interdisciplinary way by making connections and creating bridges between realms. In addition, I was privileged to become PREDICT’s representative during a USAID-FAO training on sample collection, sample preservation and transport where I was part of the national zoonoses surveillance workforce. All this training and exposure has been a spring board in my career that earned me an internship with the WHO global influenza program.”

FACES OF PREDICT

LIBERIA

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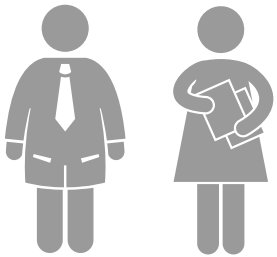
Global Health Security Agenda

WORKFORCE DEVELOPMENT

28 STAFF

9 OTHER



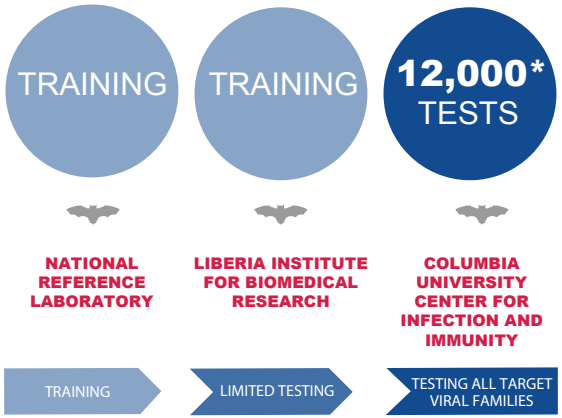
26 MALE | 11 FEMALE

ONE HEALTH SURVEILLANCE

5,386 INDIVIDUALS

32,344 SPECIMENS

LAB STRENGTHENING



*As part of the Ebola Host Project, samples are being tested at Columbia University to accelerate release of viral findings for use for decisikon-making and risk mitigation efforts.

P2 IMPACT

37 trained in One Health skills

5,386 animals sampled

12,000 tests for Ebola and other filoviruses

www.predict.global

PREDICT/ Liberia field team sampling bats in Lofa County, Liberia.
Photo: PREDICT/ Liberia

REPUBLIC OF THE CONGO

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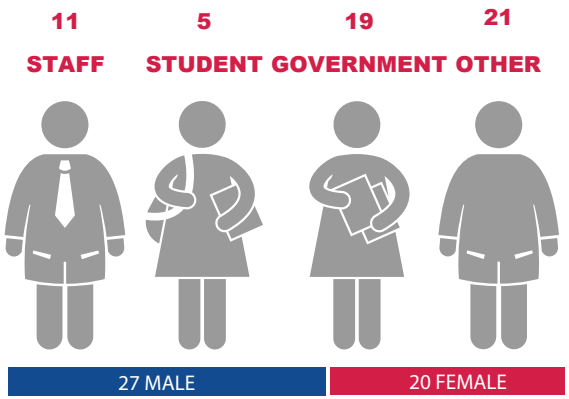
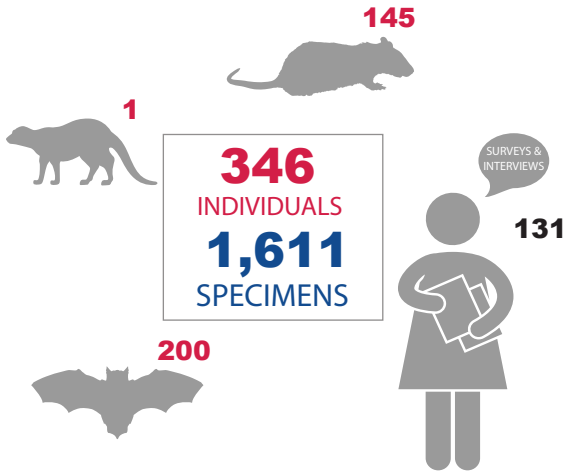
FROM THE AMERICAN PEOPLE

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

4,461* TESTS

INSTITUT NATIONAL RECHERCHE BIOMEDICALE (INRB)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

*To date, animals specimen testing has been conducted by partners at the Institut National Recherche Biomedicale (INRB) in DR Congo.

P2 IMPACT

47 trained in One Health skills

346 individuals sampled

131 individuals interviewed

4,461 tests for 5 viral families

VIRUSES DETECTED

55
NEW
VIRUSES

14
KNOWN
VIRUSES

www.predict.global

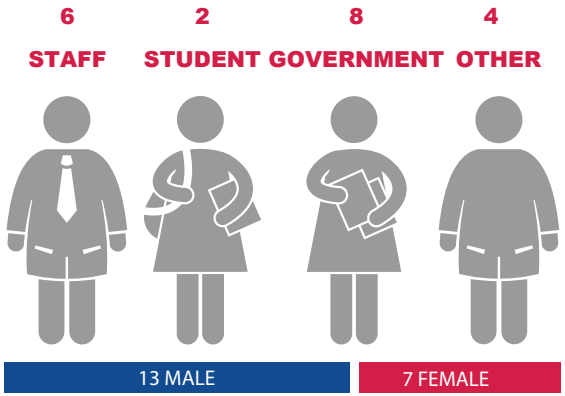
PREDICT-1

RWANDA

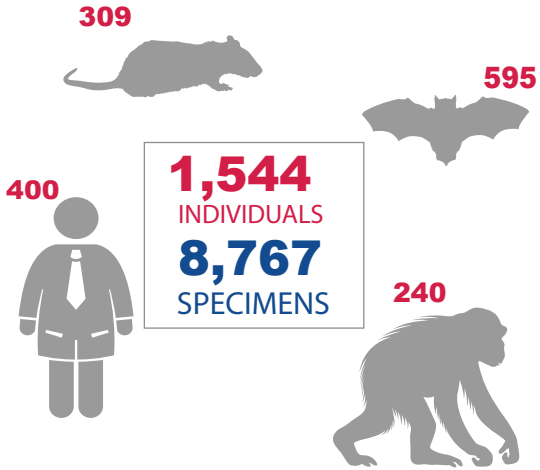
USAID | PREDICT

FROM THE AMERICAN PEOPLE

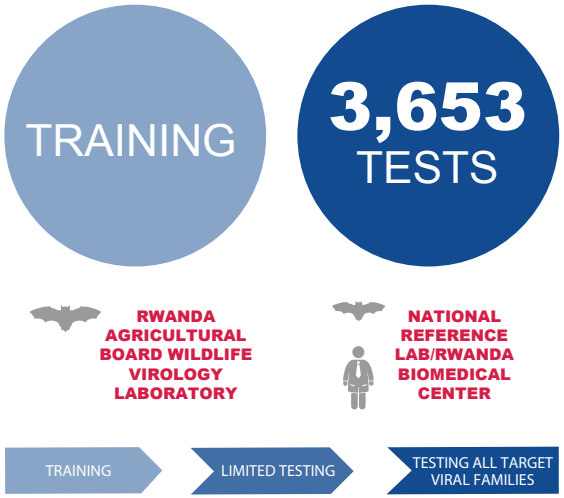
WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING



P2 IMPACT

20 trained in One Health skills

1,544 individuals sampled

400 individuals interviewed

3,653 tests for 4 viral families

8 unique viruses detected

www.predict.global

VIRUSES DETECTED

16 NEW VIRUSES

11 KNOWN VIRUSES

PREDICT-1

2 NEW VIRUSES

2 PREDICT-1 VIRUSES

4 KNOWN VIRUSES

PREDICT-2

JEAN CLAUDE TUMUSHIME

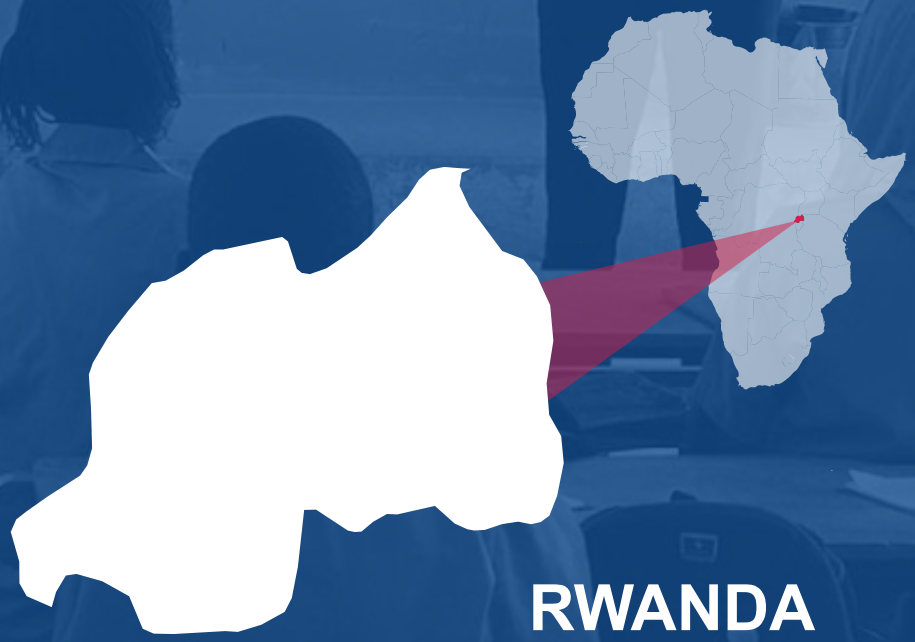
PREDICT/Rwanda Field Veterinarian & Laboratory Technician
Gorilla Doctors

Dr. Jean Claude Tumushime is PREDICT/Rwanda's field veterinarian and laboratory technician, a true One Health position he has held for the last three years, and that he calls, "…a life-changing experience for my professional career in many ways." He cites the initial intensive training in molecular techniques as enabling him to go on to perform hundreds of PCR assays on a variety of wildlife samples for the detection of viral pathogens in wildlife that could pose a significant threat to public health.

Having only recently graduated from veterinary school, Jean Claude was hired after conducting a one-year internship with Gorilla Doctors, PREDICT/Rwanda's lead implementing partner. Right away, Jean Claude was immersed in all aspects of the project, which helped him develop skills in safe capture and handling of wildlife, wildlife sampling, laboratory safety, sample handling and storage, and electronic record-keeping, all of which substantially augmented his veterinary education and the initial training he had as a veterinarian with Gorilla Doctors.

"This has been a unique opportunity that allowed me to be part of a global team that is involved in detecting and discovering pathogens that can threaten the world. I feel proud of being part of a team that is at the forefront of generating information that could help both the public health and conservation sectors to design interventions that could deter the next pandemic threat.

"PREDICT taught me how to build bridges with partners and stakeholders. I will not forget the time that our PREDICT team worked with staff from our Rwanda Agriculture Board and Rwanda Development Board (the government's wildlife authorities) when there was an outbreak of Avian Influenza in Uganda; even though we had not detected Avian Influenza in Rwanda, we travelled the whole country working together to sensitize people to the importance of the disease, and to prepare communities for conducting surveillance and sampling on birds if necessary. Working with PREDICT equipped me with skills on how to deal with any disease outbreak that can emerge from wild animals."



SENEGAL

USAID | PREDICT
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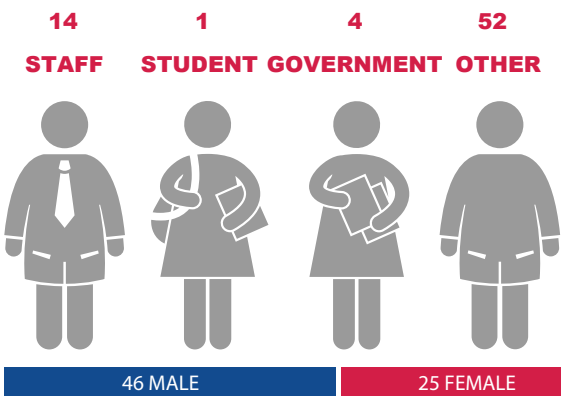
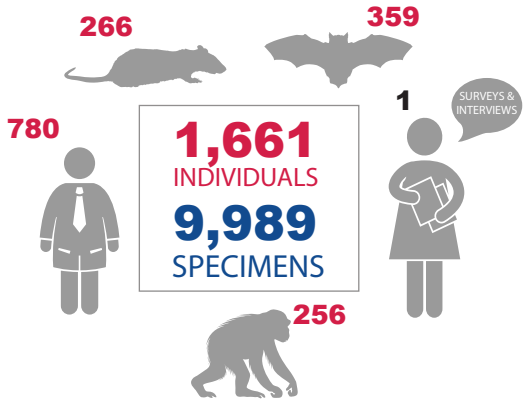
Global Health Security Agenda

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

4,903 TESTS

3,808 TESTS

L'INSTITUT SENEGALAIS DE RECHERCHES AGRICOLES (ISRA)

CHEIKH ANTA DIP UNIVERSITY (UCAD)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

71 trained in One Health skills

1,661 individuals sampled

781 individuals interviewed

8,711 tests for 5 viral families

www.predict.global

Dr. Amadou Ndiaye, PREDICT animal sampling lead, collects wildlife samples at a field site.
Photo: PREDICT/ Senegal

FACES OF PREDICT

DABA ZOUMAROU

PREDICT/Senegal Laboratory Technician
DANTEC Laboratory at
Checikh Anta Diop University

"Research helps to perpetuate and strengthen the scientific skills of a laboratory. Additionally, USAID's PREDICT helped strengthening our lab with the latest generation equipment, helped diversifying our research center activities and train our young researchers."

* * *

"In Senegal, the laboratory plays a central role in the One Health approach by supporting multi-sectoral surveillance and decision-making. USAID PREDICT strengthened LNERV as the reference laboratory of the West African Organization in Animal Health for the detection and identification of potentially pandemic viruses (Filovirus, Coronavirus, etc.) as well as in the Regional Network of Laboratories of West and Central Africa for transboundary diseases."

MODOU MOUSTAPHA LO

PREDICT/Senegal Lead for Viral Detection in Animals
University ISRA/LNERV-Virology

SENEGAL

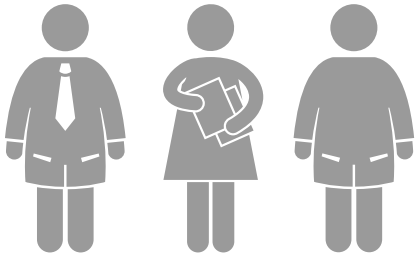
SIERRA LEONE

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

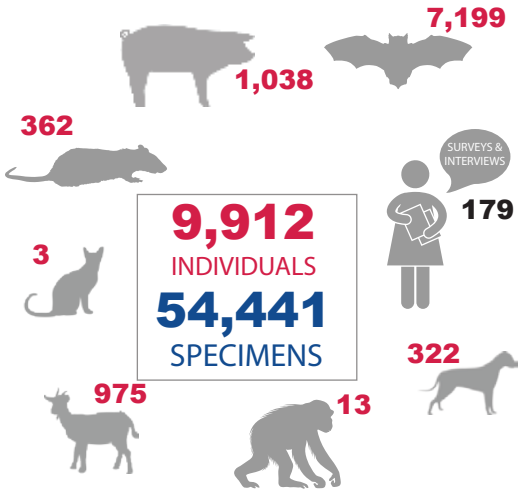
WORKFORCE DEVELOPMENT

31	6	88
STAFF	GOVERNMENT	OTHER

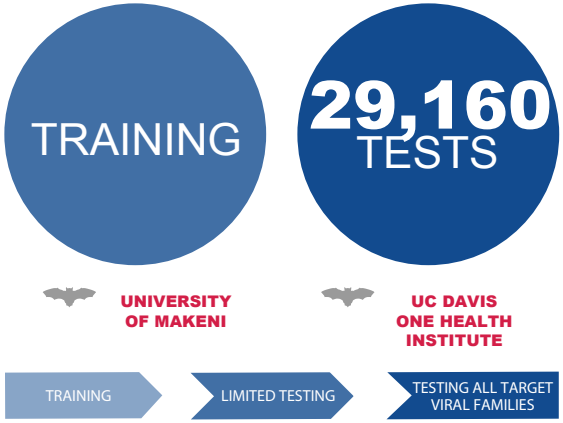


91 MALE | 32 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING



*As part of the Ebola Host Project, samples are being tested at UC Davis to accelerate release of viral findings for use for decision-making and risk mitigation efforts.

P2 IMPACT

123 trained in One Health skills

9,912 individuals sampled

179 individuals interviewed in behavioral risk investigations

29,160 tests for Ebola and other filoviruses

1 unique virus detected

www.predict.global

VIRUSES DETECTED

1
NEW VIRUS

PREDICT-2

Photo: Simon Townsley

Photo: Simon Townsley

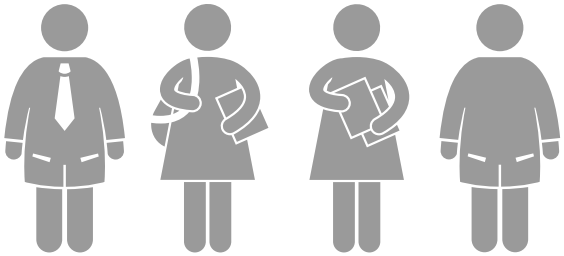
TANZANIA

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

WORKFORCE DEVELOPMENT

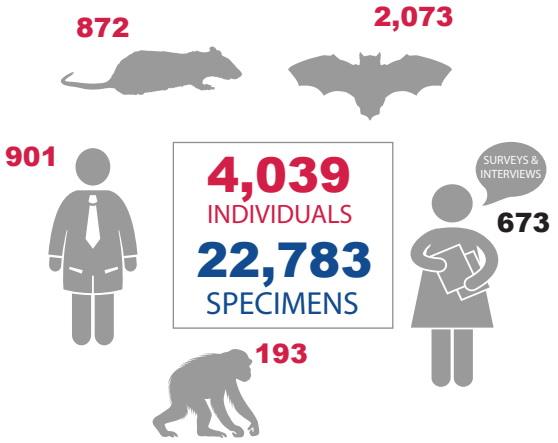
35	29	22	28
STAFF	STUDENT	GOVERNMENT	OTHER



37 MALE | 65 FEMALE

*1 individual gender not recorded

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

5,069 TESTS

14,488 TESTS

IFAKARA HEALTH INSTITUTE

SOKOINE UNIVERSITY

TRAINING | LIMITED TESTING | TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

103 trained in One Health skills

4,039 individuals sampled

1,574 individuals interviewed in behavioral risk investigations

19,557 tests for 5 viral families

VIRUSES DETECTED

50 NEW VIRUSES

12 KNOWN VIRUSES

www.predict.global

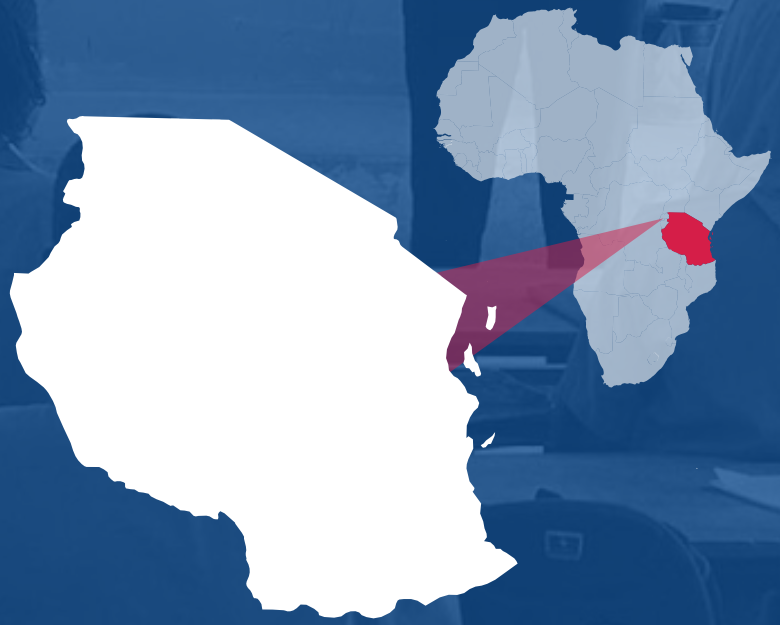
PREDICT-1

GRACE MWANGOKA

PREDICT/Tanzania Human Surveillance Lead
Ifakara Health Institute

Dr. Grace Mwangoka, from Mbeya, Tanzania is the PREDICT/Tanzania Human Surveillance Lead at the Ifakara Health Institute. She was instrumental in effectively launching human surveillance with clinic and health facility partners and has been with the project for three years. Dr. Mwangoka is a veterinarian by training (BVM and MPVM) but has been working as a public health professional for most of her career, a training path that equips her well for leading One Health projects and communicating across both human and animal health sectors. During community sensitization meetings, she had the opportunity to educate communities on zoonotic diseases and try to link some of their livelihoods as predisposing factors for acquiring infections. Earlier this year, Grace was given an opportunity to train and support PREDICT colleagues in Ethiopia.

"There is a lot to be done in battling zoonotic disease using One Health concept which is still in its infancy in my country. Given the opportunity I would very much like to be involved in working with the government on increased surveillance efforts to detect, monitor and predict pathogens that have potential to cause epidemics. I also hope to contribute to continue capacity building work so that more professionals understand the importance of One Health and actively work together. Through the mentorship of PREDICT senior scientist I have been given an opportunity to lecture on the One Health Concept to the Master of Science in Public Health Research at Nelson Mandela African Institution of Science and Technology. This is the MSc course established by IHI and Nelson Mandela Institute. From this experience I saw another side of me and had a chance to strengthen my career on One health through sharing of knowledge and skills I have gained."



TANZANIA

UGANDA

USAID | PREDICT
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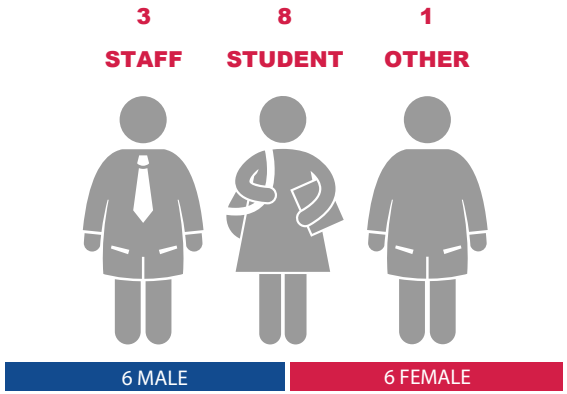
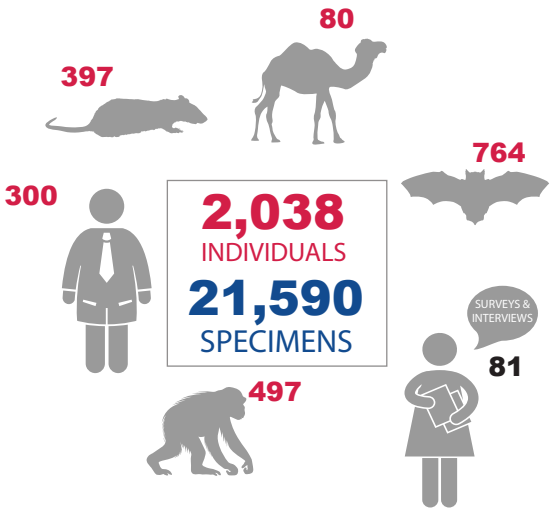
Global Health Security Agenda

WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

3,303 TESTS

UGANDA VIRAL RESEARCH INSTITUTE

4,248 TESTS

MAKERERE UGANDA WALTER REED PROJECT

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

12 trained in One Health skills

2,038 individuals sampled

381 individuals interviewed in behavioral risk investigations

7,551 tests for 5 viral families

VIRUSES DETECTED

39
NEW
VIRUSES

17
KNOWN
VIRUSES

www.predict.global

PREDICT-1

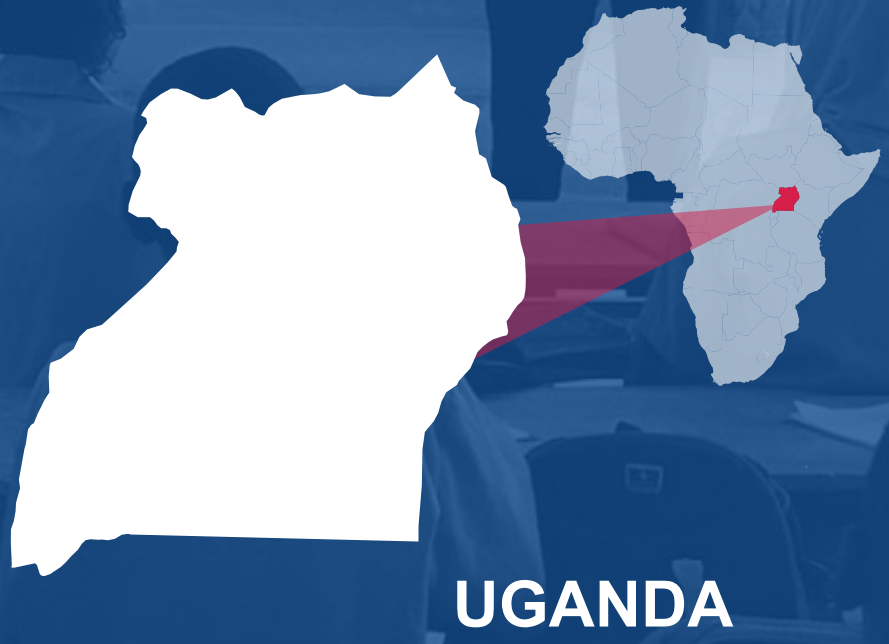
RICKY OKELLO OKWIR

PREDICT/Uganda Field Veterinarian
Gorilla Doctors

Dr. Ricky Okello Okwir has served as PREDICT's field veterinarian in Uganda since 2014. He joined the staff of Gorilla Doctors during the final year of his Master's degree in Global Health and Infectious Diseases at the University of Edinburgh, during which he studied foamy viruses in wild and captive non-human primates. Okwir grew up in Northern Uganda on the shores of Lake Kyoga, sharing he ecosystem with wildlife, in a place where hunting was a common economic activity in the community; Okwir witnessed some wildlife populations decline to near zero before his eyes.

While in veterinary school, Okwir's eyes were further opened to the conservation threats facing wildlife in Uganda, and he resolved to follow his hopes and dreams of becoming a wildlife veterinarian. As PREDICT's field veterinarian, Okwir has safely and humanely sampled more than 2,000 wild bats, rodents and primates, and has been particularly adept at managing Uganda's data in PREDICT's centralized database, EIDITH. In fact, he has proven to be one of the EIDITH team's most trusted users.

"I was compelled to enter the veterinary profession at an early age of just 10 years after suffering a traumatic incident in our remote village. I watched a mother squirrel and her baby speared by a group of hunters. I rescued the squirrels, and as a young school-going child, took care of the two squirrels from just my basic knowledge of simple wound treatment that I had learned in school. The mother squirrel survived, but unfortunately, the baby squirrel died in my arms. It was at that point that I dedicated my life and talents to helping all creatures great and small."



FACES OF PREDICT

BANGLADESH

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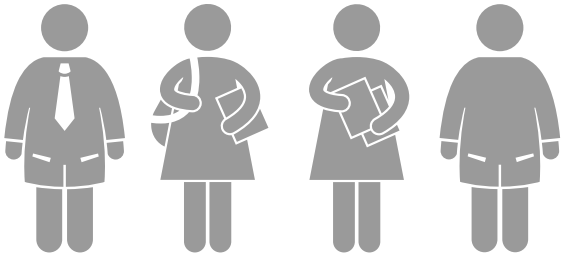
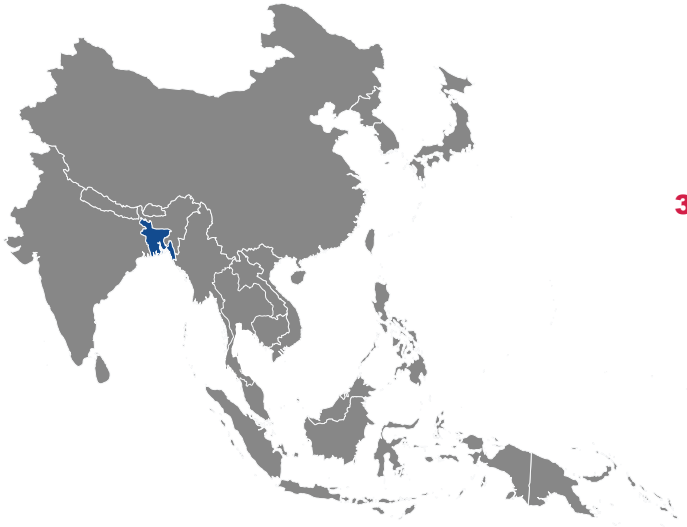
Global Health Security Agenda

WORKFORCE DEVELOPMENT

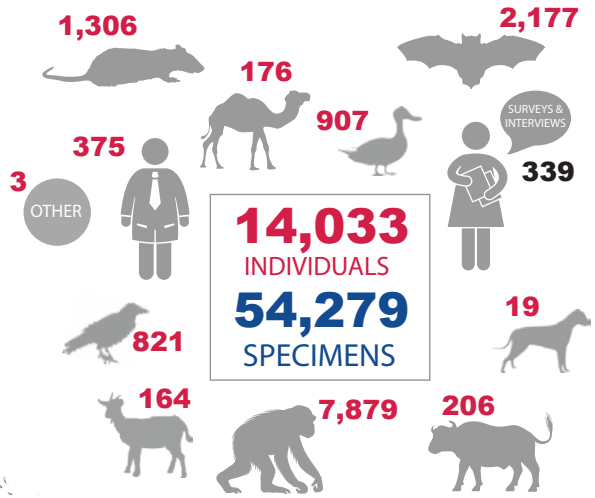
27	74	10	15
STAFF	STUDENT	GOVERNMENT	OTHER



92 MALE | 28 FEMALE



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

6,812 TESTS

43,144 TESTS

INSTITUTE OF EPIDEMIOLOGY DISEASE CONTROL AND RESEARCH

INTERNATIONAL CENTRE FOR DIARRHEAL DISEASE RESEARCH BANGLADESH

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

120 trained in One Health skills
14,033 individuals sampled
714 individuals interviewed
49,956 tests for 5 viral families
20 unique viruses detected

www.predict.global

VIRUSES DETECTED

PREDICT-1	PREDICT-2
217 NEW VIRUSES	**7** NEW VIRUSES
	4 PREDICT-1 VIRUSES
20 KNOWN VIRUSES	**9** KNOWN VIRUSES

NAFIS RAHMAN

PREDICT/Bangladesh Clinical Research Associate
IEDCR and Faridpur Medical College

Dr. Nafis Rahman joined IEDCR after finishing a year-long internship after graduation from medical school in 2017. Dr. Rahman's father is also a doctor and she grew up exposed to humanitarian work and service to society at a very early age. This inspired her to study medicine and become a doctor herself so that she could help people and her community as a whole.

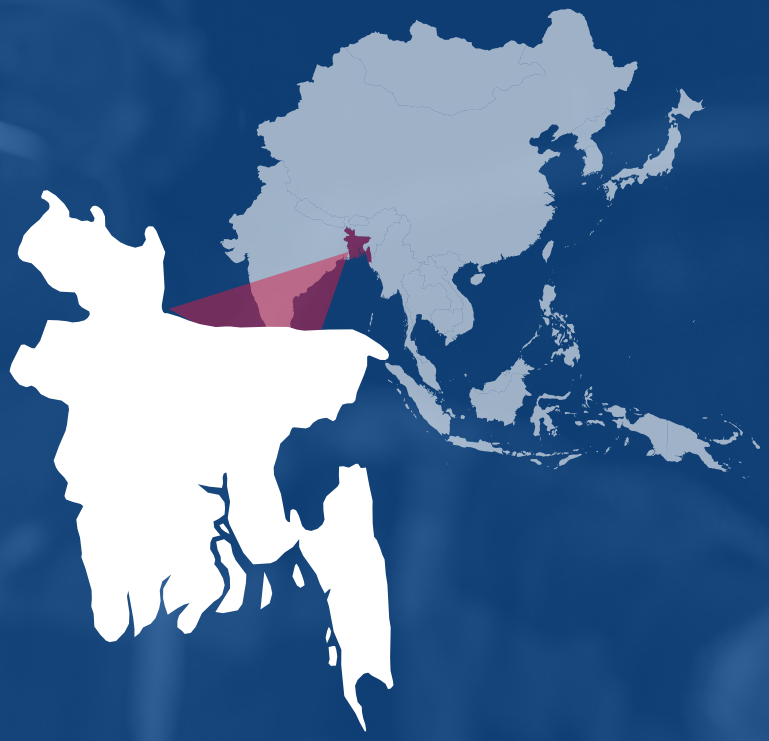
She began her education at Vidyamoyee Government Girls School, matriculated to Muminunninsa Women's College, Mymensingh, and culminated her academic progression following admission to Faridpur Medical College in 2011.

"I still can remember the days when I was so fascinated with the public health topics in my community medicine class, that I'd dream of being a researcher to help the larger community to prevent diseases and other illness. I knew the road would not be smooth, but I still kept on going holding my hope of being a researcher.

When I joined IEDCR, I knew it would be a great opportunity for me to learn and prove myself in the arena of research. With IEDCR I work on the probability of infectious diseases with a viral cause. I assess the patients to determine the appropriate subjects to enroll in our study and then collect relevant biological sample types from them to look for the presence of priority viruses. We also conduct a questionnaire to learn about the participants contact with animals and other possible exposures.

The work with PREDICT can be a challenging job, especially for a woman it can be hard to be accepted as a researcher in the context of Bangladesh. People are not used to seeing girls getting out of their cocoons to join the productive and challenging work.

This is one of the reasons why I love my job, it is challenging and productive. I feel lucky to be a part of a project that is working to prevent future diseases and epidemics. It always thrills me that what we are doing today may help shape better health of the future community. I plan to continue my journey of helping mankind and the planet as a whole through the work of my research."



BANGLADESH

FACES OF PREDICT

CAMBODIA

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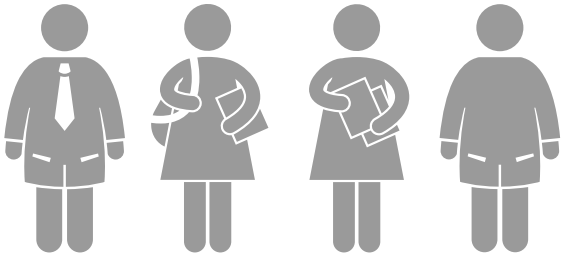
Global Health Security Agenda

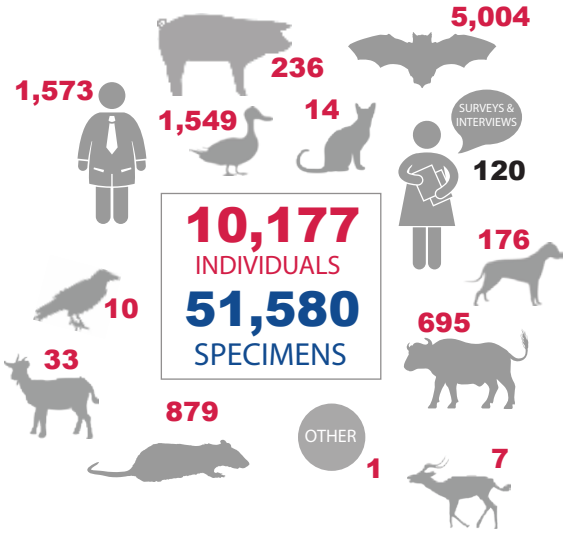
WORKFORCE DEVELOPMENT

14	24	26	17
STAFF	STUDENT	GOVERNMENT	OTHER



49 MALE | 30 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

58,689 TESTS

INSTITUT PASTEUR DU CAMBODGE

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

- **79 trained** in One Health skills
- **10,177 individuals sampled**
- **1,693 individuals interviewed**
- **58,689 tests** for 8 viral families
- **14 unique viruses** detected

www.predict.global

VIRUSES DETECTED

PREDICT-1	PREDICT-2
29 NEW VIRUSES	**2** NEW VIRUSES
	13 PREDICT-1 VIRUSES
18 KNOWN VIRUSES	**6** KNOWN VIRUSES

FACES OF PREDICT

CHANTHEN VAN

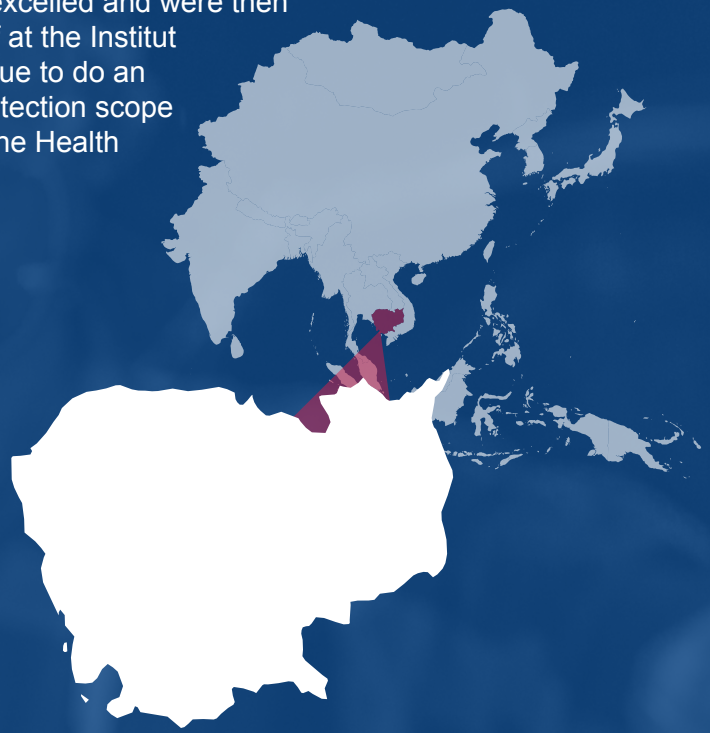
PREDICT/Cambodia
Laboratory Technician
Institut Pasteur du Cambodge

LEAKHENA PHUM

PREDICT/Cambodia
Laboratory Technician

PREDICT's work in Cambodia has always prioritized capacity building, including training of final-year students from multiple disciplines in field and laboratory work, giving students theoretical and practical training in a safe and ethical One Health approach to sampling and testing animals and humans for viral detection. Through these efforts PREDICT is helping to build the future workforce in Cambodia: emphasizing the best possible biosafety practices from the field to the laboratory, performing viral surveillance and respond to zoonotic disease outbreaks; and strengthening health professional's understanding of the need for good cross-sectoral communication and collaboration.

Chanthen Van and Leakhena Phum are laboratory technicians working to detect viruses at the PREDICT lab. Both were students (studying Bio-Engineering and Veterinary Science, respectively) who participated in field and laboratory training and activities under the PREDICT project and completed their final-year research theses on coronaviruses in rodents and bats in Cambodia with supervision from the PREDICT/Cambodia team. They excelled and were then hired as part of the laboratory staff at the Institut Pasteur du Cambodge, and continue to do an excellent job on the critical viral detection scope of this ambitious and innovative One Health project.



CAMBODIA

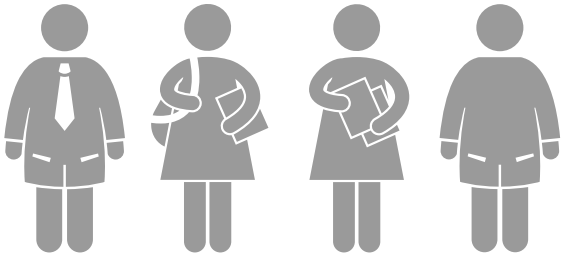
CHINA

USAID | PREDICT

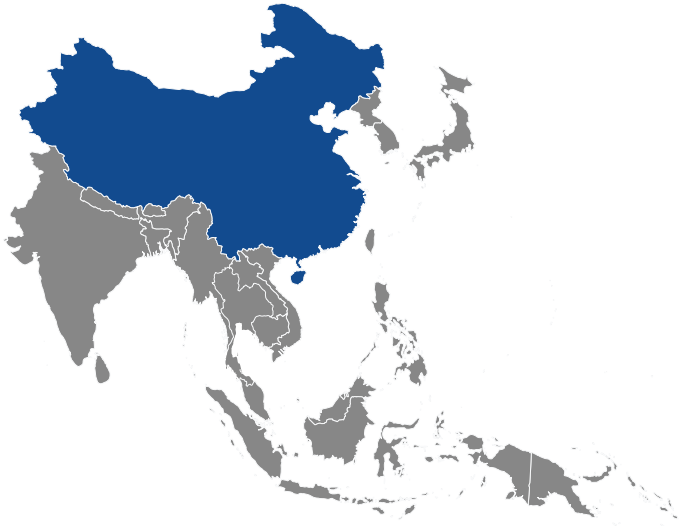
FROM THE AMERICAN PEOPLE

WORKFORCE DEVELOPMENT

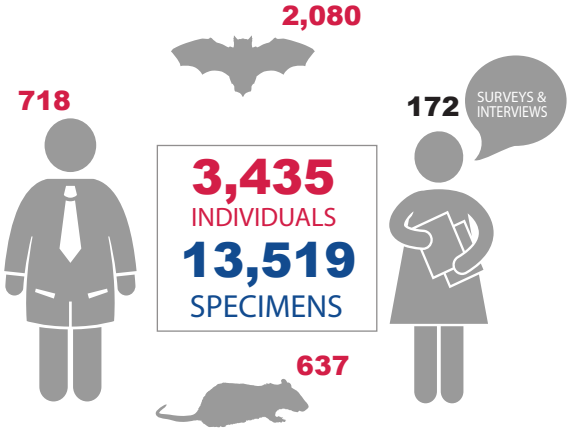
31	7	18	32
STAFF	STUDENT	GOVERNMENT	OTHER



40 MALE | 40 FEMALE



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

15,071 TESTS

1,526 TESTS

WUHAN INSTITUTE OF VIROLOGY

GUANGDONG CDC

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

80 trained in One Health skills

3,435 individuals sampled

890 individuals interviewed

16,597 tests for 5 viral families

27 unique viruses detected

www.predict.global

VIRUSES DETECTED

PREDICT-1	PREDICT-2
46 NEW VIRUSES	**11** NEW VIRUSES
	4 PREDICT-1 VIRUSES
22 KNOWN VIRUSES	**12** KNOWN VIRUSES

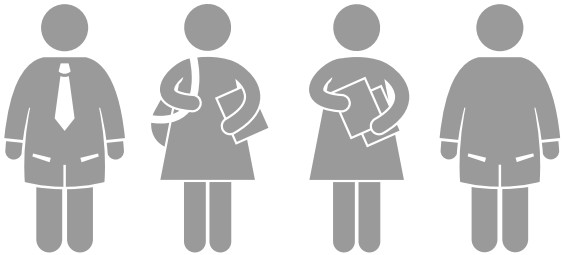
INDIA

USAID | PREDICT
FROM THE AMERICAN PEOPLE

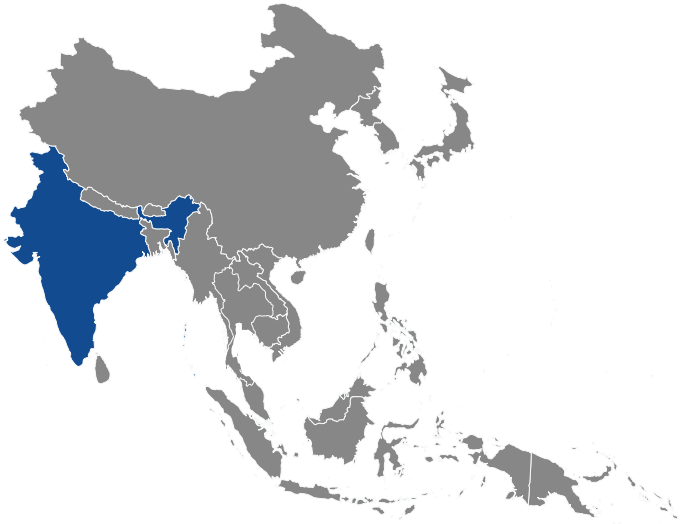
Global Health Security Agenda

WORKFORCE DEVELOPMENT

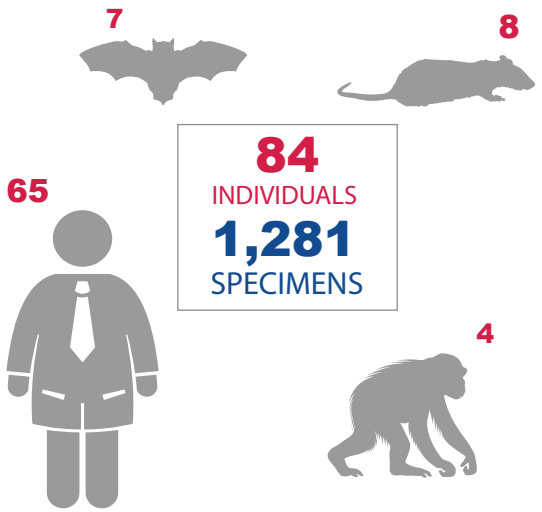
15	1	0	4
STAFF	STUDENT	GOVERNMENT	OTHER



15 MALE | 5 FEMALE



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

378
TESTS

SANJAY GHANDI POSTGRADUATE INSTITUTE OF MEDICAL SCIENCES

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

20 trained in One Health skills

84 individuals (humans & animals) sampled

65 individuals interviewed

378 tests for 5 viral families

PREDICT/India laboratory team performs molecular tests to detect viruses at the Sanjay Gandhi Post-Graduate Institute of Medical Sciences.

Photo: PREDICT/India

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INDONESIA

USAID | PREDICT
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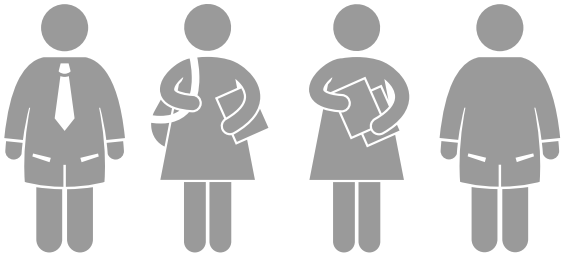
Global Health Security Agenda

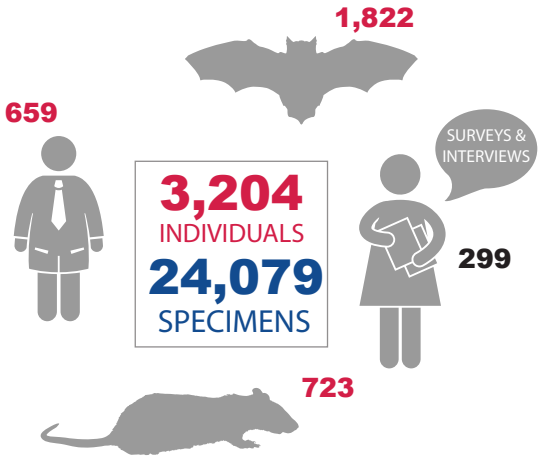
WORKFORCE DEVELOPMENT

23	1	19	140
STAFF	STUDENT	GOVERNMENT	OTHER



63 MALE | 120 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

2,298 TESTS

31,388 TESTS

EIJKMAN INSTITUTE FOR MOLECULAR BIOLOGY (EIMB)

PRIMATE RESEARCH CENTER BOGOR AGRICULTURAL UNIVERSITY

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

183 trained in One Health skills
3,204 individuals sampled
958 individuals interviewed
33,686 tests for 5 viral families
25 unique viruses detected

VIRUSES DETECTED

11
NEW VIRUSES

3
KNOWN VIRUSES

PREDICT-1

www.predict.global

FACES OF PREDICT

SURYO SAPUTRO

PREDICT/Indonesia Field Veterinarian
Primate Research Center
Bogor Agricultural University

"Saving our wildlife is also saving us. PREDICT is the key to increase awareness about future zoonotic disease emergence"

AGENG WIYATNO

PREDICT/Indonesia Junior Researcher
Eijkman Institute for Molecular Biology

"PREDICT is a great opportunity to improve our knowledge and skills in infectious disease research. PREDICT allows me to contribute to science and society."

Dr. Suryo Saputro and Ageng Wiyatno have been part of PREDICT/Indonesia team since 2012. Suryo, a veterinarian, is the PREDICT Country Coordinator's assistant and a field veterinarian at the Primate Research Center of Bogor Agricultural University. Ageng Wiyatno is a junior researcher at the Eijkman Institute for Molecular Biology in Jakarta. Both of them have been strongly involved in PREDICT field work, successfully implementing field surveillance activities and coordinating biological sample collection from animals and humans, respectively, in communities with high risk of exposure to viral zoonosis in Sulawesi.

Ageng graduated at the Biochemistry Department of Bogor Agricultural University. In addition to his field surveillance activities, he is leading the laboratory testing of PREDICT human samples at the Eijkman Institute and has contributed to provide important data on the prevalence of several known and neglected viruses in Indonesia. Suryo trained as a Doctor of Veterinary Medicine at the Gadjah Mada University in Jogjakarta. Since 2005, he has been involved in avian influenza surveillance in wild and captive birds from Java island and participated in several bird sampling trips. He is also very active in primate conservation and is the coordinator and veterinarian of the animal conservation facility at the Primate Research Center of Bogor Agricultural University.

Ageng and Suryo are also very active in building capacity for virology research and zoonotic disease surveillance in Indonesia. They delivered training sessions on basic virology, biosafety and animal sampling for staff from hospitals, universities, and ministries, improving the standard of biosafety and animal welfare for biological sampling in Indonesia. Ageng also disseminated and translated knowledge and experience gained from PREDICT's research into stories and articles in local language to increase awareness on viral zoonosis.

Ageng and Suryo are also very active in building capacity for virology research and zoonotic disease surveillance in Indonesia. They delivered training sessions on basic virology, biosafety and animal sampling for staff from hospitals, universities, and ministries, improving the standard of biosafety and animal welfare for biological sampling in Indonesia. Ageng also disseminated and translated knowledge and experience gained from PREDICT's research into stories and articles in local language to increase awareness on viral zoonosis.

INDONESIA

LAO PDR

USAID | PREDICT
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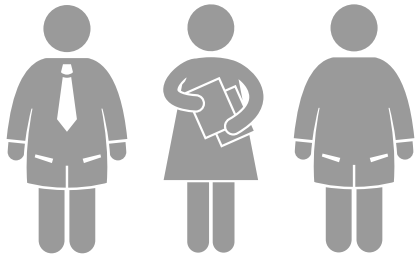
Global Health Security Agenda

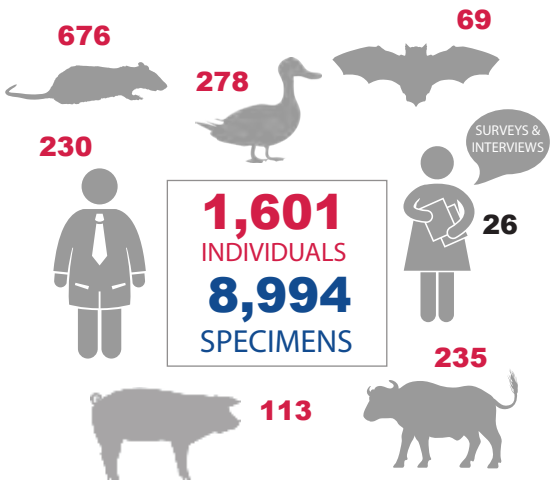
WORKFORCE DEVELOPMENT

30 STAFF | 19 GOVERNMENT | 8 OTHER



22 MALE | 19 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

10,291 TESTS

NATIONAL ANIMAL HEALTH LABORATORY

3,213 TESTS

NATIONAL CENTER FOR LABORATORY AND EPIDEMIOLOGY (NCLE)

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

41 trained in One Health skills
1,601 individuals sampled
256 individuals interviewed
13,504 tests for 5 viral families
1 unique virus detected

VIRUSES DETECTED

16 NEW VIRUSES

5 KNOWN VIRUSES

PREDICT-1

1 KNOWN VIRUS

PREDICT-2

www.predict.global

SOUPHATSONE HOUATTHONGKHAM

PREDICT/Laos PDR Epidemiologist
Ministry of Health

Souphatsone Houatthongkham ("Sone") has been working as an epidemiologist for the Lao PDR Ministry of Health at the National Center for Laboratory and Epidemiology since 2010, and recently completed a Master's degree in Health Care Administration from Nagoya University in Japan in 2017. Sone played a vital role in the collection and management of PREDICT-2 human behavioral data in Champasack province, working as the liaison between the provincial surveillance officer, district surveillance officer, and healthcare workers at Khong District Hospital. Sone completed PREDICT training, including biosafety and lab safety, behavioral research, syndromic surveillance, and human subject research ethics in 2017, and went on to conduct ethnographic interviews of community members at high-risk interfaces, and collect demographic and behavioral information from patients with syndromes of interest at the Khong District Hospital. Sone also assisted the PREDICT global and country management team by providing ongoing guidance to the human behavioral research personnel in the field. Sone was experienced in surveillance reporting, outbreak investigation, and research, prior to his involvement with the PREDICT Project. Though experienced, he gained valuable insights and career experience through the project, most notably developing skills in the social sciences: effective ethnographic interviewing and behavioral data collection and management.

"I was honored to be part of the PREDICT project. This project has given us important information regarding zoonotic diseases. I am now more aware of zoonotic viruses circulating in Laos, and I have better understanding of the attitudes and practices that put people at risk of zoonotic disease. Data from this project can inform future interventions and prevention measures, and has created a basis for further research in Laos. I would like to acknowledge the PREDICT-2 project for the support and experience I gained in the field."

LAO PDR

FACES OF PREDICT

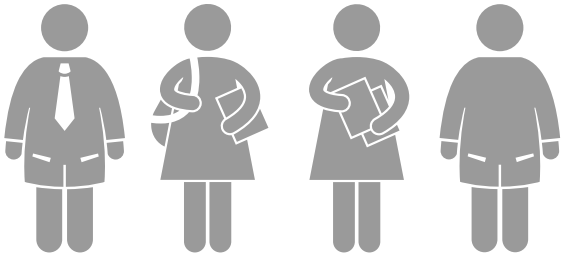
MALAYSIA

USAID | PREDICT
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

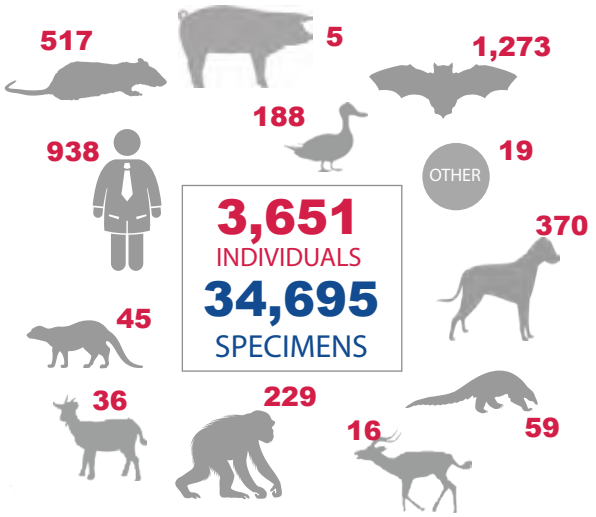
WORKFORCE DEVELOPMENT

38	19	243	24
STAFF	STUDENT	GOVERNMENT	OTHER



175 MALE | 146 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

22,248 TESTS	5,649 TESTS	11,970 TESTS	5,908 TESTS
WILDLIFE HEALTH, GENETIC AND FORENSIC LABORATORY, SABAH WILDLIFE DEPARTMENT	VIROLOGY LAB, FACULTY OF VETERINARY MEDICINE, UNIVERSITY PUTRA MALAYSIA	PERHILITAN NATIONAL WILDLIFE FORENSIC LABORATORY	NATIONAL PUBLIC HEALTH LABORATORY PENINSULAR MALAYSIA

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

321 trained in One Health skills

3,651 individuals (humans & animals) sampled

938 individuals interviewed

45,775 tests for 5 viral families

21 unique viruses detected

www.predict.global

VIRUSES DETECTED

57 NEW VIRUSES

23 KNOWN VIRUSES

PREDICT-1

16 NEW VIRUSES

3 PREDICT-1 VIRUSES

3 KNOWN VIRUSES

PREDICT-2

ZAHIDAH IZZATI ZEID

PREDICT/Malaysia Veterinarian
EcoHealth Alliance (based in Malaysia)

Dr Zahidah was initially exposed to conservation medicine through her three-year tenure at Zoo Negara Malaysia, where she developed a great interest in wildlife conservation and rescue. To pursue this, she then spent three months in South Korea as an intern at the Chungnam Wild Animal Rescue Centre, before working as the veterinarian at the Laos Wildlife Rescue Centre. In October 2017, Dr. Zahidah became the veterinarian for EcoHealth Alliance in Malaysia. Dr. Zahidah was keen to return home to protect Malaysian wildlife and was excited to work with an organization actively promoting One Health through the PREDICT project.

Dr. Zahidah has quickly become an important member of the PREDICT team in Malaysia working closely with government partners to build capacity to reduce the likelihood of spillover events. Dr. Zahidah is passionate and concerned about the plight of wildlife in Malaysia and their predicament. Dr. Zahidah is directly involved with the sampling of free ranging and captive wildlife, livestock and domestic animals for the purpose of disease surveillance and screening for novel pathogens. Dr. Zahidah is responsible for animal health and welfare and ensuring all activities meet the requirements of the Institutional Animal Care and Use Committee. She helps to organize and leads field trips working closely with Sabah Wildlife Health Unit to complete the Deep Forest sampling in Telupid.

In May 2018, Dr. Zahidah was selected by the US Embassy in Malaysia to apply for The International Visitor Leadership Program. If she is successful in her application, she will spend 3 weeks in the USA in 2019 observing how the One Health approach is being implemented in the United States. In October 2018, Dr. Zahidah represented PREDICT/Malaysia at the 11th Meeting of the Asian Society of Conservation Medicine in Bali, where she presented a poster “Usage of Inhalation Anaesthesia for Wild Rodents in a Field Setting” detailing the use of a gas anaesthesia machine in the field and the protocol she has developed to shorten the duration that animals are held in captivity greatly reducing animal stress.

MALAYSIA

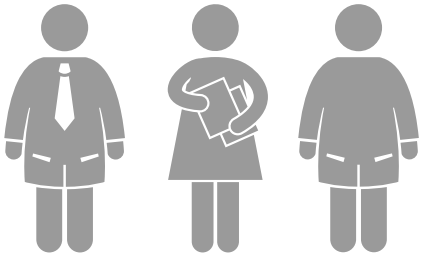
FACES OF PREDICT

MONGOLIA

USAID | PREDICT
FROM THE AMERICAN PEOPLE

WORKFORCE DEVELOPMENT

8	60	9
STAFF	GOVERNMENT	OTHER



51 MALE | 25 FEMALE

ONE HEALTH SURVEILLANCE

3,238

3,238 INDIVIDUALS
6,660 SPECIMENS

LAB STRENGTHENING

4,200 TESTS

STATE CENTRAL VETERINARY LABORATORY

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

76 trained in One Health skills
3,238 animals sampled
4,200 tests for influenza viruses
1 unique virus detected

VIRUSES DETECTED

1
KNOWN VIRUS

www.predict.global

PREDICT-2

FACES OF PREDICT

ARIUNBAATAR BARKHASBAATAR

PREDICT/Mongolia Avian Specialist
State Central Veterinary Laboratory

Ariunbaatar graduated from the National University of Mongolia in 2015 with a degree in biology. He is an experienced bird spotter currently doing my master's degree on raptor populations in Mongolia. He has been working as an avian specialist on the PREDICT project since 2016. Through the PREDICT project, he has led spring and fall field surveys for three regions in Mongolia. These surveys included shoreline transects, post-mortem examinations of dead and sick birds, and collection of guano samples. For instance, at Sangiin Dalai Lake, he identified bird species and counted the number of dead, while conducting the shoreline transect to detect sick and dead birds around lake. I have got a lot of field experience and wildlife disease knowledge from PREDICT, especially bird necropsy and sample collection.

"I am really interested in wildlife disease in the future." -Ariunbaatar Barkhasbaatar

* * *

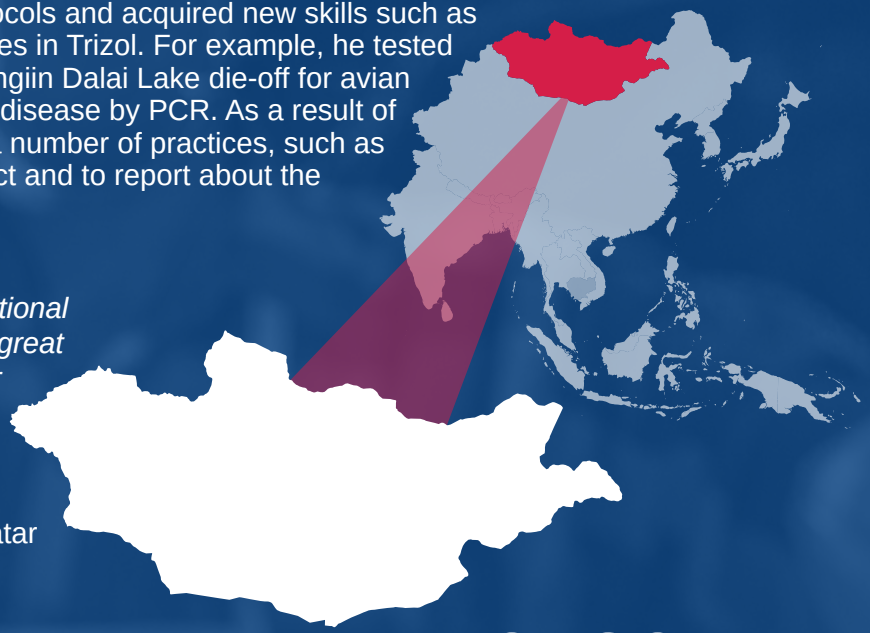
ULAANKHUU ANKHANBAATAR

PREDICT/Mongolia Virologist
State Central Veterinary Laboratory

Ulaankhuu is a veterinarian but he has been working as virologist at State Central Veterinary Laboratory since 2014 and in 2016 he successfully finished my masters on non-infectious disease at Veterinary School, Mongolian University of Life Science. He obtained knowledge about avian influenza virus through trainings at The University of Hong Kong's School of Public Health and experience with diagnosis of avian influenza virus at Hokkaido University in Japan between 2015 and 2017. He has been working on PREDICT laboratory efforts, testing samples collected from wild birds at target sites since 2016. Through the PREDICT project, he has gained a lot of laboratory experience using the PREDICT protocols and acquired new skills such as RNA extraction on samples in Trizol. For example, he tested the samples from the Sangiin Dalai Lake die-off for avian influenza and Newcastle disease by PCR. As a result of this project, he has had a number of practices, such as how to work on the project and to report about the results.

"Working with the international project team has been a great opportunity for my further research. Also my bird identification has improved."

-Ulaankhuu Ankhanbaatar



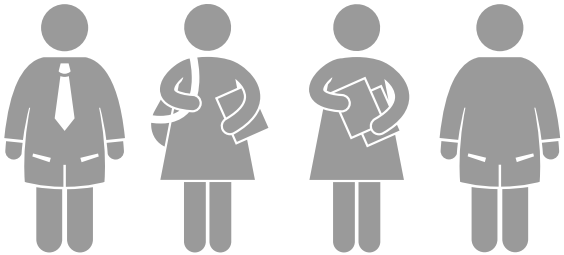
MONGOLIA

MYANMAR

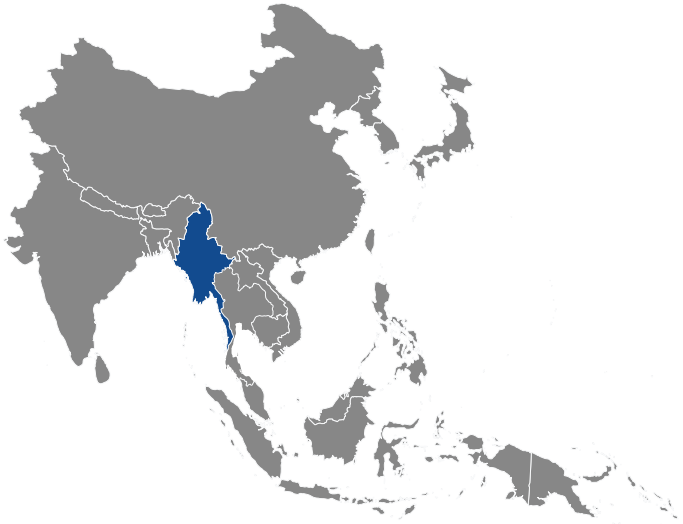
USAID | PREDICT
FROM THE AMERICAN PEOPLE

WORKFORCE DEVELOPMENT

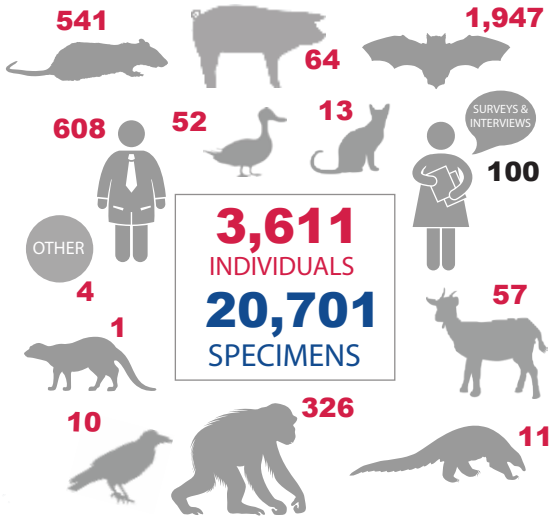
8	28	59	393
STAFF	STUDENT	GOVERNMENT	OTHER



168 MALE | 320 FEMALE



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

2,040 TESTS — LIVESTOCK BREEDING AND VETERINARY DEPARTMENT*

2,220 TESTS — DEPARTMENT OF MEDICAL RESEARCH

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

*Samples were tested at UC Davis during training of DMR lab technicians. 4,284 tests were conducted at UC Davis across 5 viral families as part of the training.

P2 IMPACT

488 trained in One Health skills

3,611 individuals sampled
708 individuals interviewed

4,260 tests for 5 viral families

2 unique viruses detected

VIRUSES DETECTED

6
NEW VIRUS

3
PREDICT-1 VIRUS

PREDICT-2

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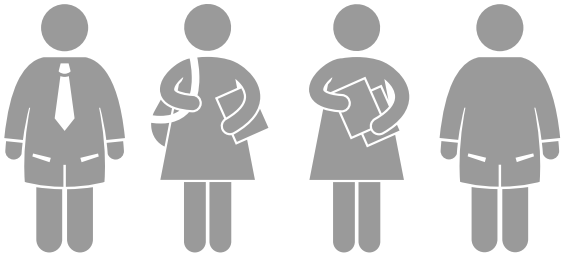
NEPAL

USAID | PREDICT

FROM THE AMERICAN PEOPLE

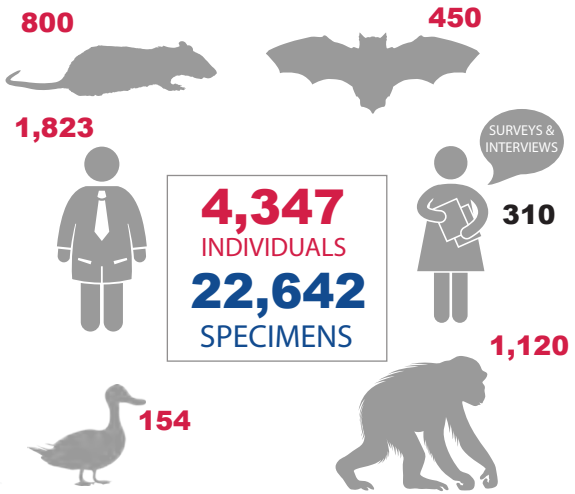
WORKFORCE DEVELOPMENT

36	0	4	3
STAFF	STUDENT	GOVERNMENT	OTHER



28 MALE | 15 FEMALE

ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

29,016 TESTS

CENTER FOR MOLECULAR DYNAMICS NEPAL/ INTREPID NEPAL

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

- **43 trained** in One Health skills
- **4,347 individuals sampled**
- **2,133 individuals interviewed**
- **29,016 tests** for 5 viral families
- **6 unique viruses** detected

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VIRUSES DETECTED

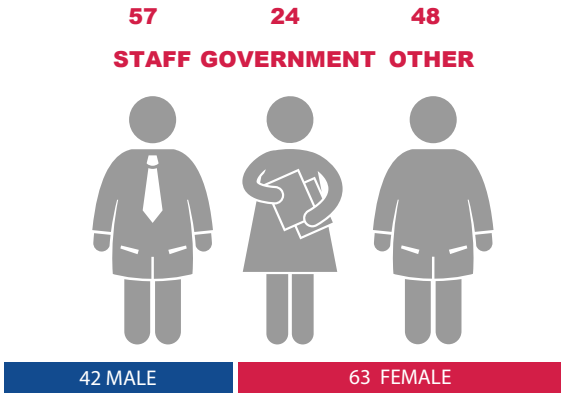
PREDICT-1	PREDICT-2
6 NEW VIRUSES	**1** NEW VIRUS
5 KNOWN VIRUSES	**5** KNOWN VIRUSES

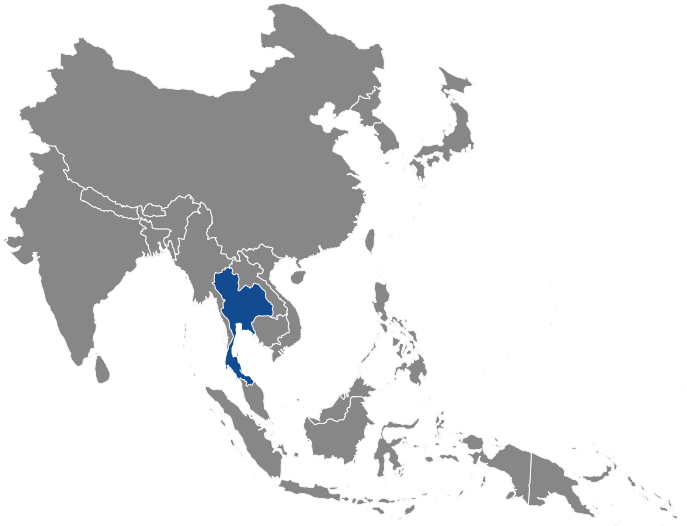
THAILAND

USAID | PREDICT
FROM THE AMERICAN PEOPLE

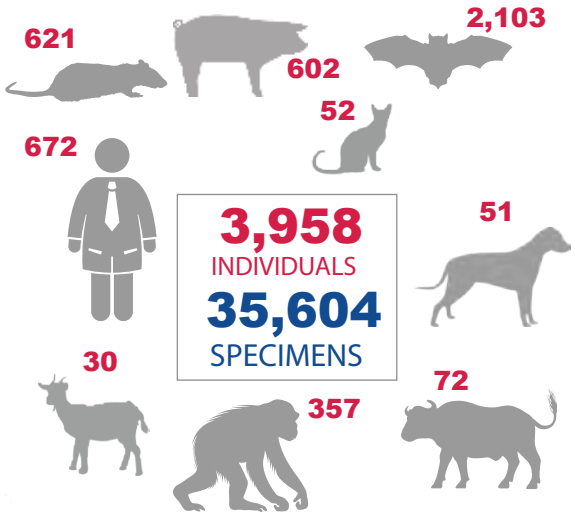
Global Health Security Agenda

WORKFORCE DEVELOPMENT





ONE HEALTH SURVEILLANCE



LAB STRENGTHENING

25,908
TESTS

WHO-CC VIRAL ZOONOSES CHULALONGKORN UNIVERSITY

TRAINING → LIMITED TESTING → TESTING ALL TARGET VIRAL FAMILIES

P2 IMPACT

105 trained in One Health skills
3,958 individuals (humans & animals) sampled
672 individuals interviewed
25,908 tests for 5 viral families
12 unique viruses detected

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VIRUSES DETECTED

PREDICT-1	PREDICT-2
83 NEW VIRUSES	**2** NEW VIRUSES
	7 PREDICT-1 VIRUSES
34 KNOWN VIRUSES	**3** KNOWN VIRUSES

FACES OF PREDICT

SUPAPORN WACHARAPLUESADEE

PREDICT/Thailand Country Coordinator
Chulalongkorn University

Dr. Supaporn Wacharapluesadee (Chu), Deputy Director of the Thai Red Cross Emerging Infectious Diseases Health Science Centre (TRC-EID), King Chulalongkorn University, has worked with the PREDICT team for more than a decade as the Thailand Country Coordinator while serving as the Deputy Director at the Thai Red Cross Emerging Infectious Diseases Health Science Centre (TRC-EID), King Chulalongkorn Memorial Hospital, Faculty of Medicine, Chulalongkorn University, a WHO Collaborating Centre for Research and Training on Viral Zoonoses. Her research interests include emerging infectious diseases in bats (including Nipah, Rabies, Coronavirus, and novel pathogens) as well as molecular diagnoses and sequencing of viruses. TRC-EID is responsible for molecular diagnoses services to the hospital, and is the reference laboratory for rabies virus, MERS-CoV, Ebola, Zika, and other infectious diseases diagnoses for Ministry of Public Health, Thailand. She has served and consulted on several WHO and Thai government committees.

***

PREDICT/Thailand conducted concurrent biological surveillance activities at high-risk animal-human interface in Chonburi province. Chonburi is a province in Central/Eastern Thailand where there is extensive swine production and mixed agricultural production. Large fruit bat colonies exist in this province where Nipah virus has been previously identified. Fruit bat foraging areas overlap with pig production sites, and the Buddhist temple that harbors bat populations is a local site of worship and tourist attraction. Therefore, there is a high risk of viral spillover from bats to humans and livestock in this region. PREDICT collected biological samples from fruit bats and people living in communities located near pig farms. Swine samples were also collected in collaboration with FAO and DLD (Department of Livestock Diseases).

THANAPOL PUTTHARAKSA

PREDICT/Thailand Head of Village Health Volunteers
Chonburi Province

"PREDICT increases community awareness."
-Thanapol Puttharaksa

Mr. Thanapol is one of the key persons supporting PREDICT community surveillance study and bat sampling in Chonburi since the first phase of the project (2009-2014). He realizes the importance of communication and education about potential EID risk from bats in communities living around fruits bat colonies and pig farms in Chonburi.

VIET NAM

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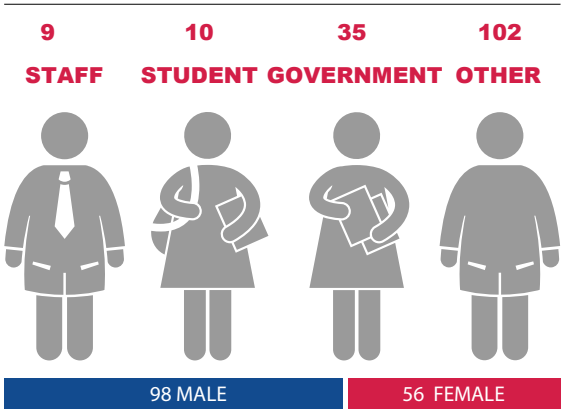
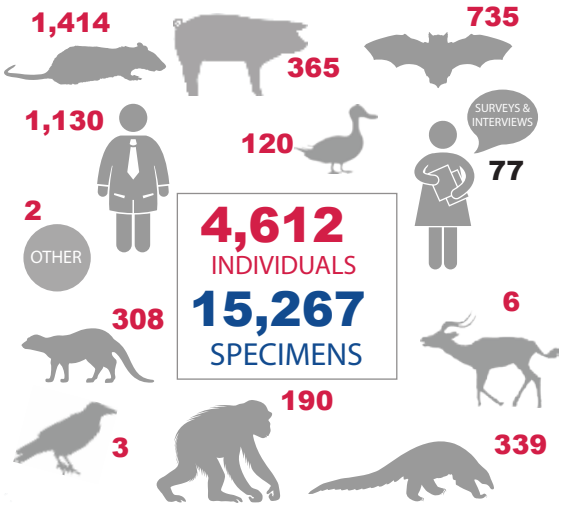
FROM THE AMERICAN PEOPLE

Global Health Security Agenda

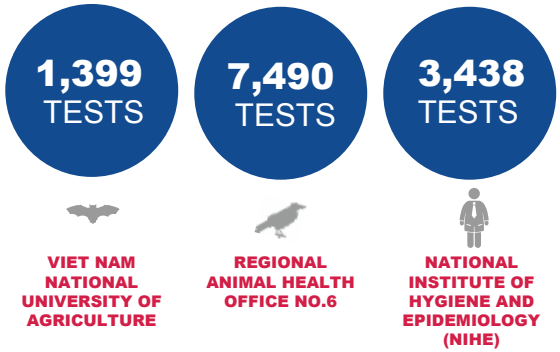
WORKFORCE DEVELOPMENT



ONE HEALTH SURVEILLANCE



LAB STRENGTHENING



P2 IMPACT

154 trained in One Health skills
4,612 individuals sampled
1,207 individuals interviewed
12,327 tests for 5 viral families
2 unique viruses detected

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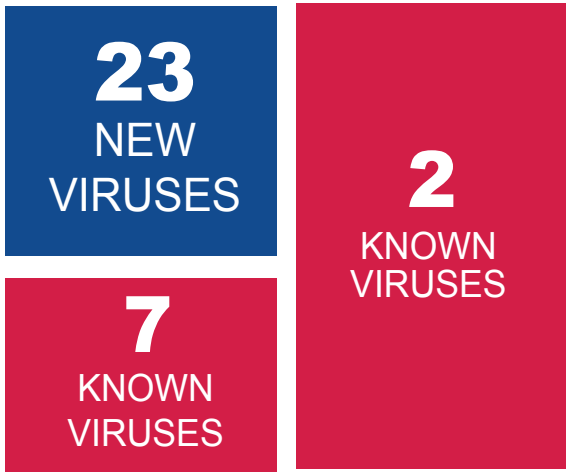
VIRUSES DETECTED



FACES OF PREDICT

NGUYEN VAN LONG

PREDICT/Viet Nam Veterinary Program Officer
Wildlife Conservation Society

"I'm happy to be a part of this team. I have chance to do my dream job and have the opportunity to work with lovely animals every day. Our team spirit and enthusiasm has the power to make each project seem easy to achieve.

Being a junior staff in PREDICT-2 Viet Nam has helped strengthen my knowledge of the dynamics of zoonotic virus evolution, spillover from animals to human, amplification, and spread; identifying the "hot spots" of high-risk diseases transmission interfaces in order to address wildlife trafficking in the region and prevent the devastating and destabilizing effects of a disease pandemic." -Nguyen Van Long

NGUYEN DUC THINH

PREDICT/Viet Nam Laboratory Technician
Viet Nam National Institute of Hygiene and Epidemiology

"PREDICT is so meaningful not only to me but also globally because of its One Health approach. This is also my first time to work together with wildlife and animal health staffs and I feel very happy to be able to be a part of it." -Nguyan Duc Thinh

VIETNAM

Photo: PREDICT/Guinea

V. PUBLICATIONS & PRODUCTS

Publications & Products

This past year, PREDICT research led to 44 publications, including over 10 original research articles, many in top-tier journals such as *Nature Microbiology* and *Emerging Infectious Diseases*. We have summarized a selection of publications provided below, highlighting practical implications for the scientific, policy, and development sectors. A complete citation list of all publications this year is also included. A comprehensive bibliography with all PREDICT publications to date may be found online at **publications.predict.global**

You can also follow PREDICT on ResearchGate to explore our current work, receive notifications of new publications, and interact with PREDICT's authors and research collaborators.

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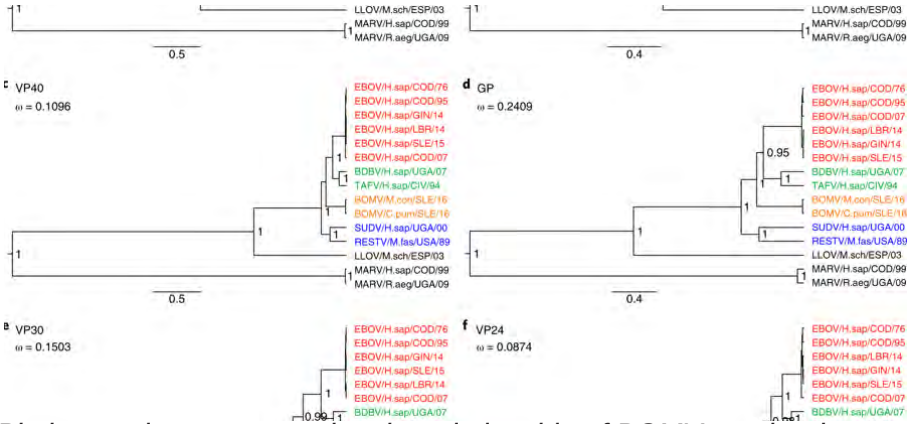
Original research highlights

The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses

In brief: Despite more than 40 years of research and continued outbreaks, the reservoirs of ebolaviruses remain unknown. Current evidence points to bats, although data is inconclusive. This study described the complete genome of a new ebolavirus, Bombali virus (BOMV) detected in free-tailed bats in Sierra Leone, specifically the little free-tailed (*Chaerephon pumilus*) and Angolan free-tailed bats (*Mops condylurus*). The bats were found roosting inside houses, indicating the potential for human transmission. At this time, further studies are required to investigate whether exposure has occurred or if BOMV is pathogenic in humans. This study provides strong evidence that bats serve as hosts for ebolaviruses and suggests that insectivorous bats play an important role in the ecology of the disease despite current focus on fruit bats. Based on findings from this study, expansion of future surveillance efforts should also include insectivorous bats.



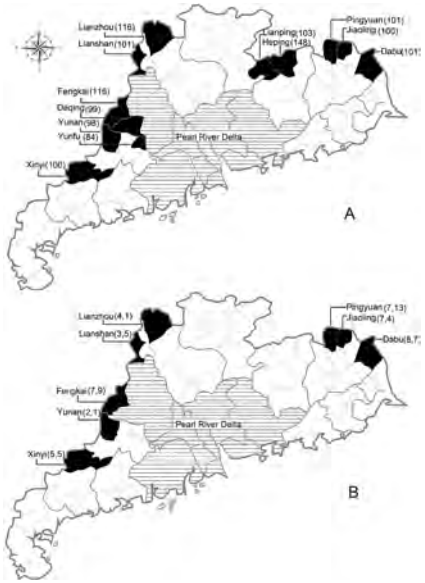
Phylogenetic tree comparing the relationship of BOMV to other known filoviruses

Citation: T. Goldstein, S.J. Anthony, A. Gbakima, B.H.Bird, J. Bangura, A. Tremeau-Bravard, M.N. Belaganahalli, H.L.Wells, J.K.Dhanota, E.Liang, M.Grodus, R.K.Jangra, V.A.DeJesus, G.Lasso, B.R.Smith, A. Jambai, B.O. Kamara, S. Kamara, W. Bangura, C. Monagin, S. Shapira, C.K.Johnson, K.Saylors, E.M. Rubin, K. Chandran, W.I.Lipkin, J.A.K.Mazet. 2018. The discovery of Bombali virus adds further support for bats as hosts of ebolaviruses. *Nature Microbiology.* 3; 1084–1089. DOI : 10.1038/s41564-018-0227-2

Serologic and behavioral risk survey of workers with wildlife contact in China

In brief: Human-wildlife interactions provide opportunities for the transmission of zoonotic pathogens from animals to humans. This study characterized behaviors and perceptions associated with transmission of pathogens with pandemic potential in highly exposed human populations at the animal-human interface in Guangdong Province, China. A combination of risk factor surveys and serologic testing was used to assess exposure to wildlife and their viral pathogens. Contact with a wide range of wildlife species was reported in both occupational and occasional contexts. The study found an overall proportion of seropositive individuals of approximately 4.0%. Moreover, persons employed as butchers demonstrated a seropositivity of 9.0% to at least one

pathogen, while hunters had lower rates of seropositivity. Several other behaviors were also correlated with seropositivity, including contact with certain wildlife species such as field rats. The results from this study demonstrate the need to further explore zoonotic risks of particular activities regarding wildlife contact.

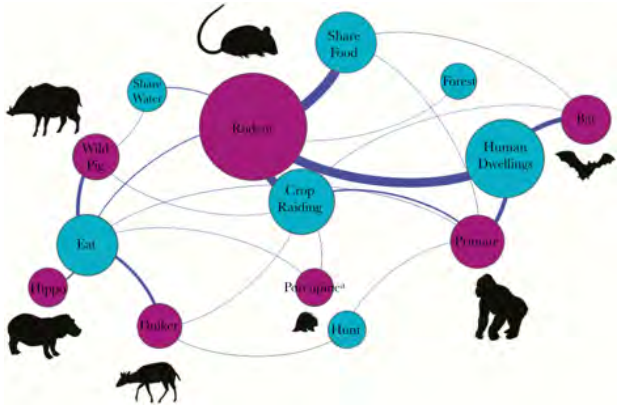


Prefecture maps of Guangdong Province, China. A) 1,267 participants were enrolled at Dabu, Jiaoling, Pingyuan, Lianping, Heping, Lianshan, Lianzhou, Yunfu, Yunan, Xinyi, Deqing and Fengkai (areas colored black). Number of respondents at each prefecture is bracketed; (B) In the brackets, in total 43 (left) seropositive respondents and 45 (right) close contacts of theirs were enrolled in the follow-up phase at Xinyi, Yunan, Fengkai, Lianshan, Lianzhou, Pingyuan, Jiaoling and Dabu (areas colored black). Together, 88 individuals participated in the follow up phase.

Citation: C. Monagin, B. Paccha, N. Liang, S. Trufan, H. Zhou, D. Wu, B.S. Schneider, A. Chmura, . Epstein, P. Daszak. 2018. Serologic and behavioral risk survey of workers with wildlife contact in China. *PLoS ONE* 13(4): e0194647. DOI: 10.1371/journal.pone.0194647

Suspected Exposure to Filoviruses Among People Contacting Wildlife in Southwestern Uganda.

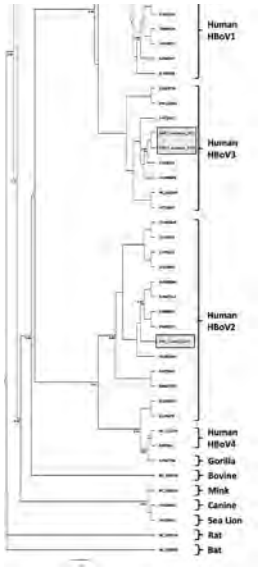
In brief: Since the discovery of filoviruses 5 decades ago, Ebola hemorrhagic fever (EHF) and Marburg hemorrhagic fever (MHF) outbreaks have become more frequent and pose great risk for regional and international spread. Increased contact between humans and wildlife in regions where wildlife hosts live or migrate is likely contributing to this rise in filovirus outbreaks. However, human and filovirus host interactions remain poorly understood. This study assessed 331 febrile patients presenting to healthcare facilities near Bwindi Impenetrable Forest in Uganda, a hot spot of mammalian biodiversity in Africa. All patients were negative for active filovirus infection by PCR analysis. However, patients were seroreactive to Sudan virus (SUDV) (4.7%), Ebola virus (EBOV) (5.3%), and Bundibugyo virus (8.9%), indicating previous exposure. Touching duikers was the most significant risk factor associated with EBOV seropositivity, while hunting primates and touching and/or eating cane rats were significant risk factors for SUDV seropositivity. These findings suggest that people with a history of wildlife contact have been previously exposed to filoviruses. Moreover, circulation of filoviruses in wild animals and subsequent spillover into humans could be more common than previously reported.



Citation: T. Smiley Evans, L. Tutaryebwa, K.V. Gilardi, P.A. Barry, A. Marzi, M. Eberhardt, B. Ssebide, M. R. Cranfield, O. Mugisha, E. Mugisha, S. Kellermann, J.A.K. Mazet, and C. K. Johnson. 2018. Suspected Exposure to Filoviruses Among People Contacting Wildlife in Southwestern Uganda. *The Journal of Infectious Diseases*. 218 (5), 22 November 2018. DOI: 10.1093/infdis/jiy251

DNA indicative of human bocaviruses detected in non-human primates in the Democratic Republic of the Congo

In brief: Bocaparvoviruses belong to the Parvovirinae family and human bocaviruses have been associated with respiratory and gastrointestinal disease. There are four known human bocaviruses, and several distinct ones in great apes. This study investigated non-human primate (NHP) bocaviruses in NHP species in the Democratic Republic of the Congo using conventional broad-range PCR. The majority of samples collected came from rural and semi-rural areas, from hunted and butchered NHPs. Samples represented 20 different NHP species, primarily red-tailed monkey (*Cercopithecus ascanius*), Wolf's monkey (*Cercopithecus wolfi)* and black crested mangabey (*Lophocebus aterrimus*). Bocavirus DNA was found in blood and tissues samples from 6 of 620 NHPs, and all isolates showed very high identity (>97 %) with human bocaviruses 2 or 3. These findings suggest that bocaparvoviruses may be able to cross species barriers and that Cercopithecus and other NHP species could be a source or reservoir for bocaviruses that have the ability to infect humans.



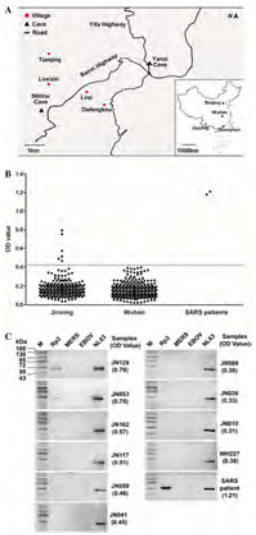
Bocavirus phylogenetic tree.

Citation: C. Kumakamba, I. Ngay Lukusa, P. Mbala Kingebeni, F. N'Kawa, J. Atibu Losoma, P.M. Mulembakani, M. Makuwa, J.J. Muyembe Tamfum, R. Belais, A. Gillis, S. Harris, A.W. Rimoin, N.A. Hoff, J.N. Fair, C. Monagin, J. Ayukekbong, E.M. Rubin, N.D. Wolfe, C.E. Lange. 2018. *Journal of General Virology* 99 (5): 676–681. DOI. 10.1099/jgv.0.001048

Serological evidence of bat SARS-related coronavirus infection in humans, China

In brief: Severe acute respiratory syndrome coronavirus (SARSCoV) caused the 2002–2003 SARS pandemic, which resulted in more than 8000 human infections worldwide and an approximately 10% fatality rate. While originally isolated from masked palm civets, current evidence suggests that bats are the natural reservoir of SARS-related coronavirus (SARSr-CoVs) However, to date, no evidence of direct transmission of SARSr-CoVs from bats to people has been reported. This study conducted serological surveillance on 218 people who live in close proximity to caves where bats that carry diverse SARSr-CoVs roost. A total of six (2.7%) positive samples were detected by ELISA. This study provides the first serological evidence of likely human infection by bat SARSr-CoVs or related viruses. The low seropositivity for the high-risk group of residents living in close proximity to bat colonies suggests that spillover is a relatively rare event.

Citation: N. Wang, S-Y. Li, X-L. Yang, H-M. Huang, Y-J. Zhang, H. Guo, C-M. Luo, M. Miller, G. Zhu, A. A. Chmura, E. Hagan, J-H. Zhou, Y-Z. Zhang, L-F. Wang, P. Daszak, Z-L. Shi. 2018. Serological Evidence of Bat SARS-Related Coronavirus Infection in Humans, China. *Virologica Sinica* 33:104–107. DOI: 10.1007/s12250-018-0012-7



SARSr-CoV serosurveillance. (A) Map of Xiyang town, Jinning County, Yunnan Province, China. Shown here is the location of the 4 villages (Tianjing, Dafengkou, Lvxi, Lvxixin) around 2 bat caves (Yanzi Cave and Shitou Cave) chosen for this study.

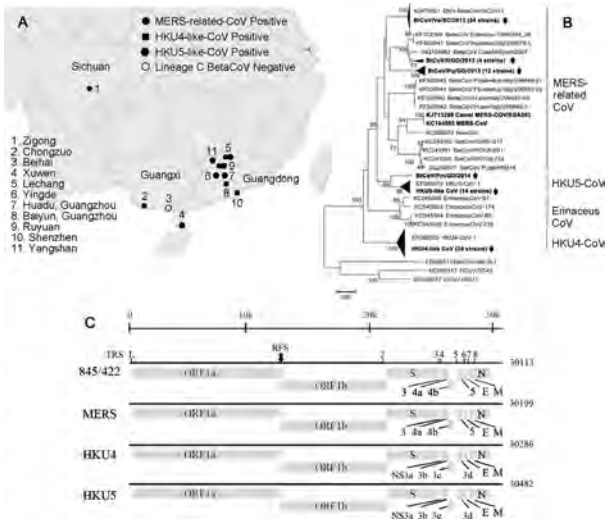
Middle East Respiratory Syndrome Coronavirus Antibodies in Dromedary Camels, Bangladesh, 2015

In brief: Middle East respiratory syndrome coronavirus (MERS-CoV), discovered in 2012, can cause fatal respiratory disease in humans. Although MERS-CoV probably originated in bats, dromedary camels (*Camelus dromedarius*) are a natural host and likely source of human MERS-CoV infection. Camel trade is a major driver of MERS-CoV movement between Africa and the Arabian Peninsula, where most human cases have occurred. In Bangladesh, camels are bred on farms and imported from India for sale in seasonal markets for ritual slaughter during religious festivals. This study, conducted in 2015, tested 36 dromedary camels at an urban farm and 19 camels at an urban market in the capital city of Dhaka for MERS-CoV. The results showed 17 (31%) were seropositive. Also, imported camels had a higher seroprevalence (52%) than domestically bred camels (4%). And those in the market had a higher seroprevalence (63%) than those on the farm (14%). All animals were PCR negative. The findings from this study suggest transmission of MERS-CoV occurs among camels in Bangladesh, yet where or when imported camels become infected is unclear. While no human cases of MERS-CoV have yet been reported in South Asia, the authors suggest that the presence of infected camels in urban markets could have public health implications and warrants further investigation.

Citation: A. Islam, J.H. Epstein, M.K. Rostal, S. Islam, Md Z.Rahman, Md E.Hossain, M S. Uzzaman, V.J. Munster, M. Peiris, M.S. Flora, M. Rahman, and P. Daszak. 2018. Middle East Respiratory Syndrome Coronavirus Antibodies in Dromedary Camels, Bangladesh, 2015. *Emerging Infectious Diseases.* 24 (5), May 2018, DOI: 10.3201/eid2405.171192.

Discovery of Novel Bat Coronaviruses in South China That Use the Same Receptor as Middle East Respiratory Syndrome Coronavirus

In brief: Middle East respiratory syndrome coronavirus (MERS-CoV) has represented a human health threat since 2012. Previous studies suggested that MERS-CoV originated in bats. However, its evolutionary path from bats to humans remains unclear. The authors screened 1,059 bat samples from at least 30 bat species collected in different regions in south China. The study discovered 89 novel lineage C betacoronaviruses in eight bat species. Full-length genome sequencing and protein-protein interaction assays were conducted on MERS-related CoV positive samples collected from a great evening bat, Ia io, in Guangdong Province. The analysis suggests that the bat MERS-related CoV uses the same host receptor as human MERS-CoV. This virus also provides evidence for a natural recombination event between the bat MERS-related CoV and another bat coronavirus, HKU4. The study expands the host ranges of MERS-related CoV and represents an important step toward establishing bats as the natural reservoir of MERS-CoV. These findings may lead to improved epidemiological surveillance of MERS-CoV and the prevention and control of the spread of MERS-CoV to humans.



Geographic locations of collection sites, phylogeny of lineage C betacoronaviruses, and genomic organization of novel bat MERS-related CoVs. (A) Map of sampling locations and lineage C betacoronaviruses detected. Names of these counties, districts, and cities are noted. (B) Phylogenetic analysis of the 228 bp RdRp genes of the newly detected lineage C betacoronaviruses. (C) Genomic organization of BtCoV/li/GD-2013-845 (845) and BtCoV/li/GD/2014-422 (422).

Citation: C-M. Luo, N. Wang, X-L. Yang, H. Z. Liu, W. Zhang, B. Li, B. Hu, C. Peng, Q-B. Geng, G-J. Zhu, F. Li, Z-L. Shi. 2018. Discovery of Novel Bat Coronaviruses in South China That Use the Same Receptor as Middle East Respiratory Syndrome Coronavirus. *Journal of Virology*. Jun 2018, 92 (13) e00116-18. DOI: 10.1128/JVI.00116-18.

Perspectives

The Global Virome Project

In brief: Our ability to mitigate disease emergence is undermined by our poor understanding of the diversity and ecology of viral threats, and of the drivers of their emergence. This paper describes a new initiative, the Global Virome Project (GVP) that will help identify the bulk of currently unknown viruses and provide timely data for public health interventions against future pandemics. The authors present the key elements of GVP and discuss the main challenges to be overcome, particularly around scale. The challenges include costs, technology for safe field sampling in remote locations and cost-effective laboratory platforms in low-income settings, and especially, how to assess the potential for novel viruses to infect people or become pandemic. The GVP would be based on a transparent and equitable strategy to share data, viral samples, and their likely products, including benefits derived from future development of medical countermeasures. The regions targeted by the GVP are largely highly biodiverse, rapidly developing countries in the tropics, which often have low capacity to deal with public health crises. It is expected that the expanded laboratory capacity, field sampling, and data generation provided by GVP would improve capacity to detect, diagnose, and discover viruses in vulnerable populations within regions most critical to preventing future pandemics.

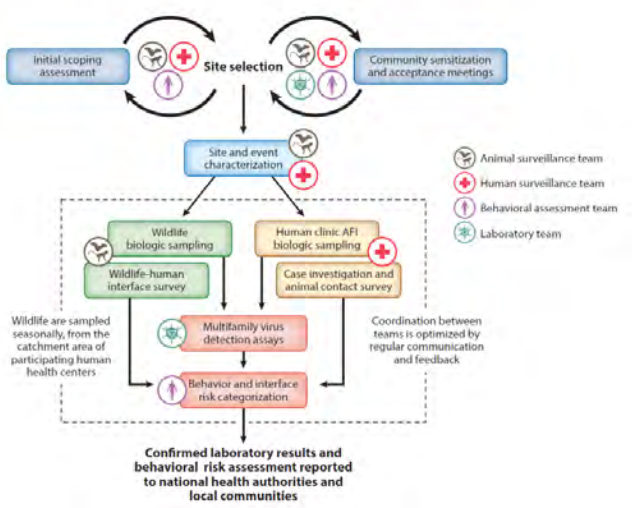
Citation: D. Carroll, P. Daszak, N.D. Wolfe, G.F. Gao, C.M. Morel, S. Morzaria, A. Pablos-Méndez, O. Tomori, J.A. Mazet. 2018. *Science*. 359(6378):872-4. DOI: 10.1126/science.aap7463

Detection of Emerging Zoonotic Pathogens: An Integrated One Health Approach

In brief: The emergence of novel zoonotic pathogens is one of the greatest challenges to global health security. Thus, a reinvigorated and sustainable pathogen detection network based on One Health principles to prevent a global pandemic is needed. The authors argue that while increasingly sophisticated diagnostics have greatly enhanced our capacity to detect and respond to disease, the initial identification of emerging pathogens must still occur at the local community level. In this paper the authors discuss factors relevant to the emerging disease paradigm, recent technical advances in diagnostic methods, and strategies for comprehensive and sustainable approaches to rapid zoonotic disease detection. From this analysis, the authors conclude that there remain massive challenges to developing robust systems capable of rapidly establishing long-term, sustainable, and

diagnostic modalities as close to the local level as feasible as a key step to rapidly identifying and alerting public health authorities and avoiding the next global pandemic. They also remark that regardless of the technology used and the scientific capacities developed, failure to engage and build trust with local political and thought leaders, traditional health workers, and community groups in disease detection and control will delay diagnosis and response, with potentially disastrous consequences. The authors stress that a One Health approach will enable recognition of the signs, identifying the threat, and rapidly working together to reduce the spread of infections and health consequences before they harm the health of animals and people throughout the world.

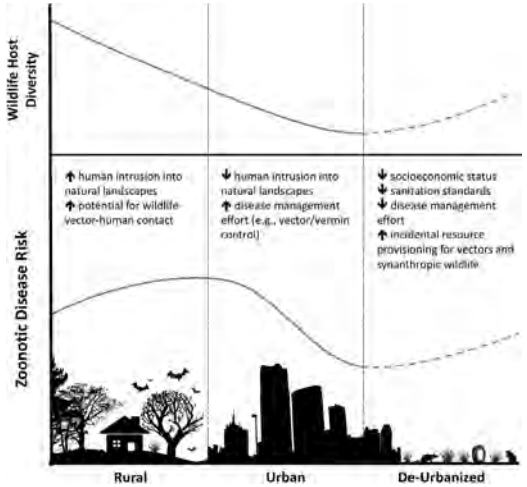
Citation: Bird BH, Mazet JAK. 2018. Detection of Emerging Zoonotic Pathogens: An Integrated One Health Approach. *Annu Rev Anim Biosci.*;6:121-139. DOI: 10.1146/annurev-animal-030117-014628.



This diagram shows how active surveillance in both human health clinics for acute febrile illnesses (AFI) and adjacent wildlife populations affords the opportunity to monitor virus spillover and disease emergence at high-risk disease transmission interfaces. The schematic is from the Health for Animals and Livelihood Improvement (HALI) virus sharing project (VISHA) implemented in central Tanzania.

De-urbanization and Zoonotic Disease Risk

In brief: In recent decades, human populations worldwide have undergone a fundamental shift from predominately rural to urban living. Anthropogenic activities are global drivers of emerging infectious diseases affecting both wildlife and humans. For example, human population density within a species' range is positively related to zoonotic pathogen richness in mammals, which in turn influences disease emergence. While the effects of urbanization on infectious disease systems in humans and animals are increasingly recognized as a research priority, the authors review the opposite but surprisingly common process: de-urbanization. The study found that the general consequences of de-urbanization for zoonotic disease risk are yet to be elucidated. However, the authors conclude that investing resources to better understand zoonotic disease patterns and processes that will arise in de-urbanizing landscapes is a worthy and achievable goal. Thus, resulting in more effective public health interventions in environments increasingly subject to cycles of intense human modification and abandonment.



Risk is likely to be lower in more highly modified and well-maintained urban environments that have lower wildlife host diversity, a reduced pathogen pool, and higher public health intervention effort. Zoonotic disease risk may increase (dashed line) in de-urbanized landscapes characterized by vacant habitats that bolster vertebrate reservoir host populations (e.g., rodents) and incidental resource provisioning (e.g., tires) that benefits vector populations.

Citation: E. Eskew, K. Olival. De-urbanization and Zoonotic Disease Risk. 2018. *EcoHealth.* DOI: 10.1007/s10393-018-1359-9

Reports and Frameworks

Operational framework for strengthening human, animal and environmental public health systems at their interface

In brief: The occurrence and impact of known and novel disease outbreaks are likely to increase with continued wide-scale changes in land use, agricultural practices, climate and weather, trade and travel, urbanization and other factors that can facilitate the risk of spillover and spread of diseases. Public health systems must therefore be resilient and prepared to face existing and future disease threats at the human-animal-environment interface. In this report to the World Bank the authors share an Operational Framework designed to provide a comprehensive overview of the One Health concept and operational guidance for One Health application (what, why, and how). Specifically, they a) provide operational guidance to directly address the need for targeted investments that prevent, prepare, detect, respond to, and recover from issues like diseases with endemic, emerging, and pandemic potential, including antimicrobial resistance; b) showcase opportunities for targeting disease threats upstream (prevention at the source, or via early detection and effective response) to help reduce the frequency and impact of emergencies the system has to react to; c) jointly yield long-term gains (and consider trade-offs) in human health, animal production, and environmental management, ultimately improving overall health of the planet and the lives, livelihoods, and well-being of people; and d) outline activities and interventions with a starting point at the human-animal-environment interface, highlight proposed methods of institutional and technical implementation, and enable mechanisms of coordination and partnership to build more collaborative public health systems. The framework is envisioned for use in existing and future projects undertaken by the World Bank and its client countries and technical partners.

Citation: F.C.J. Berthe, T. Bouley, W.B. Karesh, F. G. Le Gall, C.C. Machalaba, C.A. Plante, R.M. Seifman. 2018. Operational framework for strengthening human, animal and environmental public health systems at their interface (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/703711517234402168/Operational-framework-for-strengthening-human-animal-and-environmental-public-health-systems-at-their-interface

Building a global atlas of zoonotic diseases

In brief: Despite the human and economic impact of viral epidemics, the world is not well enough prepared for the next emerging viral outbreak. Estimations show that there are more than 1.6 million mammalian and waterfowl viruses, spanning 25 viral families known to cause human infections. Compared to just over 260 viruses known in humans, the unknown viruses represent 99.9 of potential zoonoses. The authors recognize that discovering and characterizing viruses in wildlife reservoirs is economically and technologically challenging. They mention, however, that recent initiatives such as the PREDICT-USAID project, have shown that systematic viral discovery, even in countries with limited laboratory infrastructure, is feasible. In this paper, the authors introduce a new initiative, the Global Virome Project (GVP). The GVP is an innovative 10-year proposed partnership to develop a global atlas of most of the planet's naturally occurring potentially zoonotic viruses. The project aims to transform the study of emerging diseases by building an unprecedented database of viruses in their ecological contexts. The authors state that this information on viral sequences, geographic ranges and host distributions will be used to drive the development of prevention efforts against future threats. Thus, this international alliance will connect the next generation of scientists, build capacity at hotspots of viral emergence and promote equitable access to data and strategies to prevent epidemics.

Citation: D. Carroll, B. Watson, E. Togami, P. Daszak, J.A.K. Mazet, C.J. Chrisman, E.M. Rubin, N. Wolfe, C.M. Morel, G.F. Gao, G. L. Burci, K. Fukuda, P. Auewarakul & O. Tomori. 2018. *Bulletin of the World Health Organization*. 96:292-294. DOI: 10.2471/BLT.17.205005.

A framework for stimulating economic investments to prevent emerging diseases

In brief: Infectious disease emergence and multidrug-resistant pathogens are among this century's defining global health challenges. Increasingly, evidence suggests that the accelerated rate at which these threats are emerging is strongly correlated with anthropogenic change on the planet. The World Bank and health and development institutions have made the case for investing in proactive, preventive measures that directly address these drivers, and for enhancing capacities that can contribute to averting the worst of their consequences. Yet, despite the pattern of costly responses and a compelling investment case for prevention, global postures remain primarily response-driven and reactive. Several methodological and knowledge limitations have frequently resulted in a general lack of awareness among policy-makers of upstream prevention opportunities, indirectly adding to resistance in adjusting priorities. The authors propose five interrelated pillars to institutionalize investment-driven approaches to risk mitigation and the transition to actionable prevention efforts. First, strengthening the evidence base demonstrating under what conditions investments in proactive and preventive disease mitigation approaches are fiscally prudent. Second, recognizing that a robust evidence base is necessary but not sufficient, and that economically informed, tested and validated innovations should be scaled. Third, promoting a set of structures that incentivize investments in risk mitigation. Fourth, mobilizing funds for this transition since development assistance for targeted prevention and control of cross-border infectious disease remains short of the levels required to be fully functional. Finally, collective commitment to treating emerging infectious disease prevention as a global public good given the inherently transboundary nature of infectious diseases and the non-rival, nonexcludable benefits of their avoidance. The authors conclude that economic principles should serve as the foundation for prioritizing preventive approaches, which could ultimately shift the existing paradigm away from infectious disease emergence as inevitability, and towards avoidance.

Citation: D.L. Schar, G.M. Yamey, C.C. Machalaba, & W.B. Karesh. 2017. A framework for stimulating economic investments to prevent emerging diseases. Bulletin of the World Health Organization, 96(2), 138-140. DOI: 10.2471/BLT.17.199547.

CITES Working Group. Simplified Procedures for Permits and Certificates: Report of the Working Group. SC70 Doc. 36. Submitted for the 17th Meeting of the CITES Standing Committee, 2018.

Other publications benefiting from PREDICT support

Assessing the distribution, roosting site characteristics, and population of *Pteropus lylei* in Thailand

Citation: A. Chaiyes, P. Duengkae, S. Wacharapluesadee, N. Pongpattananurak, K. Olival, T. Hemachudha. 2017. Assessing the distribution, roosting site characteristics, and population of Pteropus lylei in Thailand. *The Raffles Bulletin of Zoology,* 65.

***Bartonella henselae* infective endocarditis with dissemination: A case report and literature review in Southeast Asia**

Citation: P. Noopetch, T. Ponpinit, C. Suankratay. 2018. Bartonella henselae infective endocarditis with dissemination: A case report and literature review in Southeast Asia. *IDCases*. 13 e00441. DOI: 10.1016/j.idcr.2018.e00441

Benefits of a one health approach: An example using Rift Valley fever

Citation: M.K. Rostal, N. Ross, C. Machalaba, C. Cordel, J.T. Paweska, & W.B. Karesh. 2018. Benefits of a one health approach: An example using Rift Valley fever. *One health* (Amsterdam, Netherlands). 5, 34-36. DOI:10.1016/j.onehlt.2018.01.001

Biosurveillance: a systematic review of global infectious disease surveillance systems from 1900 to 2016

Citation: A.G. Huff, T. Allen, K. Whiting, F. Williams, L. Hunter, Z. Gold, L.C. Madoff, W.B. Karesh. 2017. Biosurveillance: a systematic review of global infectious disease surveillance systems from 1900 to 2016. *Rev. Sci. Tech. Off. Int. Epiz.* 36 (2), 513-524 DOI: 10.20506/rst.36.2.2670

Determination of hematological and serum biochemical reference values for indigenous sheep (Ovies aries) in Dhaka and Chittagong Districts of Bangladesh

Citation: Md. K. Rahman, S. Islam, J. Ferdous, Md. H. Uddin, M. B. Hossain, M. M. Hassan, A. Islam. 2018. Determination of hematological and serum biochemical reference values for indigenous sheep (*Ovies aries*) in Dhaka and Chittagong Districts of Bangladesh. *Veterinary World.* 11(8), 1089-1093. DOI: 10.14202/vetworld.2018.1089-1093

Discovery of a rich gene pool of bat SARS-related coronaviruses provides new insights into the origin of SARS coronavirus

Citation: B. Hu, L.P. Zeng, X.L. Yang, X.Y. Ge, W. Zhang, B. Li, J.Z. Xie, X.R. Shen, Y.Z. Zhang, N. Wang, D.S. Luo, X.S. Zheng, M.N. Wang, P. Daszak, L.F. Wang, J. Cui, Z.L. Shi. 2017. Discovery of a rich gene pool of bat SARS-related coronaviruses provides new insights into the origin of SARS coronavirus. *PLoS pathogens*. 13(11), e1006698. DOI: 10.1371/journal.ppat.1006698

Emerging infectious disease risk: shared drivers with environmental change

Citation: C. Machalaba, W.B. Karesh. 2017. Emerging infectious disease risk: shared drivers with environmental change. *Rev. Sci. Tech. Off. Int. Epiz.* 36 (2), 435-444. DOI: 10.20506/rst.36.2.2664

Evidence of Australian Bat Lyssavirus Infection in Diverse Australian Bat Taxa

Citation: H.E. Field. 2018. Evidence of Australian bat lyssavirus infection in diverse Australian bat taxa. *Zoonoses Public Health.* 65:742–748. DOI : 10.1111/zph.12480

Fatal swine acute diarrhoea syndrome caused by an HKU2-related coronavirus of bat origin

Citation: P. Zhou, H. Fan, T. Lan, X. Yang, W. Shi, W. Zhang, Y. Zhu, Y-W. Zhang, Q-M. Xie, S. Mani, Z-S. Zheng, B. Li, J-M, Li, H. Guo, G-Q. Pei, X-P. An, J-W. Chen, L. Zhou, K-J. Mai, J-Y. Ma. 2018. Fatal swine acute diarrhoea syndrome caused by an HKU2-related coronavirus of bat origin. *Nature*, 556. DOI: 10.1038/s41586-018-0010-9.

First report on subconjunctival dirofilariasis in Thailand caused by a *Dirofilaria sp.* closely related to *D. hongkongensis*.

Citation: P. Sukudom, A. Phumee, P. Siriyasatien. 2018. First report on subconjunctival dirofilariasis in Thailand caused by a *Dirofilaria sp.* closely related to *D. hongkongensis*. *Academia Journal of Scientific Research*. 6(3), 114-116. DOI: 10.15413/ajsr.2017.0179

Food for contagion: synthesis and future directions for studying host–parasite responses to resource shifts in anthropogenic environments.

Citation: S. Altizer, D.J. Becker, J.H. Epstein, K.M. Forbes, T.R. Gillespie, R.J. Hall, D.M. Hawley, S.M. Hernandez, L.B. Martin, R.K. Plowright, D.A. Satterfield, D.G. Streicker. 2018. Food for contagion: synthesis and future directions for studying host-parasite responses to resource shifts in anthropogenic environments. Philosophical transactions of the Royal Society of London, Series B, Biological sciences. 373(1745). DOI: 10.1098/rstb.2017.0102

Genetic Diversity of Dengue-4 Virus Strains Isolated from Patients During a Single Outbreak of Dengue Fever, Thailand

Citation: N. Nitatpattana, Y. Moné, M.A.R. Gouilh, K. Chaiyo, Y. Joyjinda, S. Ratchakum, S. Wacharapluesadee, S. Yoksan, T. Hemachudha, F. Veas, T. Vincent, J. P. Gonzalez. 2018. Genetic Diversity of Dengue-4 Virus Strains Isolated from Patients During a Single Outbreak of Dengue Fever, Thailand. *Journal of Fever.* 2(1009)

Global hotspots and correlates of emerging zoonotic diseases

Citation: T Allen, K.A. Murray, C. Zambrana-Torrelio, S.S. Morse, C. Rondinini, M. Di Marco, K.J. Olival, P. Daszak. 2017. Global hotspots and correlates of emerging zoonotic diseases. *Nature Communications*. 8, 1124. DOI: 10.1038/s41467-017-00923-8.

Identification and molecular characterization of Bovine Herpesviruses (BoHV) DNA terminase partial gene in ACEH cattle

Citation: L. Prayitno, U. Saepuloh, N.L.P.I. Mayasari, F. Faisal, E. D. Ayuningsih, J. P. Pamungkas. 2017. Identification and molecular characterization of Bovine Herpesviruses (BoHV) DNA terminase partial gene in ACEH cattle. *Jurnal Kedokteran Hewan*. 11(4). DOI: 10.21157/j.ked.hewan.v11i4.8024

Infectious Causes and Infectious Mimics of Acute Encephalitis: A Prospective Study from Thailand.

Citation: B. Skulsujirapa, S. Wacharapluesadee, S. Petcharat, T. Hemachudha, A.W. Saraya, O. Putcharoen. 2017. Infectious Causes and Infectious Mimics of Acute Encephalitis: a Prospective Study from Thailand. *Open Forum Infect Dis.* 4(1). DOI: 10.1093/ofid/ofx163.710

Insecticidal activity of Thai botanical extracts against Development stages of German cockroach, *blattella germanica* (L) (Orthoptera: blattellidae)

Citation: S. Saenmanot, A. Insung, J. Pumnuan, A. Tawatsin, U. Thavara, A. Phumee, F. Gay, W. Tachaboonyakiat, P. Siriyasatien. 2018. Insecticidal activity of Thai botanical extracts against Development stages of German cockroach, *blattella germanica (L)* (Orthoptera: blattellidae). *Southeast Asian J Trop Med Public Health.* 49(1), 46-59.

In the Media

PREDICT was featured in a number of films/videos, radio programs, news articles, and press releases, further extending the project's global reach. Links to news and other media are found on the PREDICT website and Twitter.

USAID FROM THE AMERICAN PEOPLE | PREDICT NEWS

Follow @PREDICTproject

Featured stories

New Ebola virus found in Sierra Leone

Over 30 international news articles were published following the announcement of PREDICT's discovery of Bombali Ebola Virus in bats in Sierra Leone.

PBS NEWS HOUR

SIERRA LEONE TELEGRAPH

"New strain of Ebola virus found in Bombali Sierra Leone – says ministry of health"

PREDICT: A One Health Preventive Effort

"PREDICT is improving global disease recognition through worldwide collaboration." -American Veterinarian

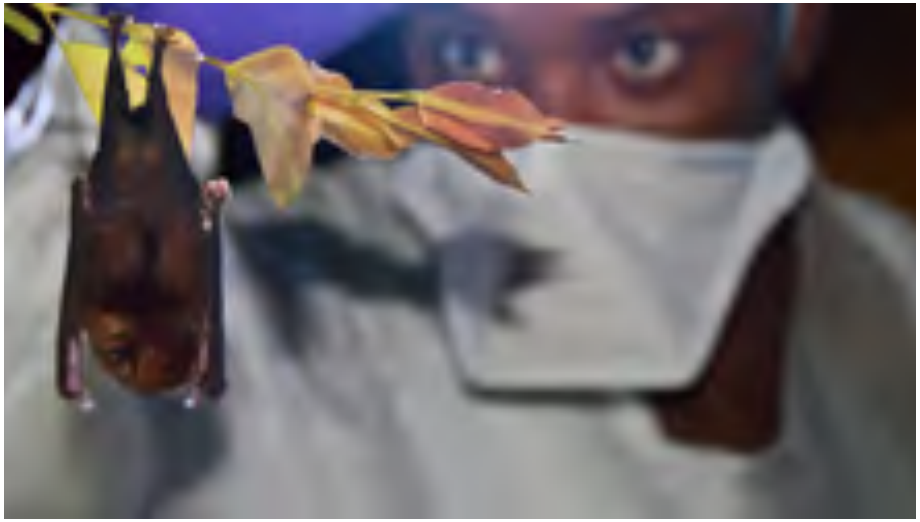
Epidemics Going Viral: Innovation vs. Nature

PREDICT's Dr. Jonna Mazet was invited to participate in a live web event hosted by the Massachusetts Medical Society and the New England Journal of Medicine, featuring Bill Gates.

Smithsonian Magazine: Can Virus Hunters Stop the Next Pandemic Before It Happens?

PREDICT's Dr. Kevin Olival joins Indonesian hunters to find the next undiscovered zoonotic virus.

AS EMERGING DISEASES SPREAD FROM WILDLIFE TO HUMANS, CAN WE PREDICT THE NEXT BIG PANDEMIC? "What can be done to reduce the likelihood that new zoonotic viruses will emerge? And how can we become better prepared to deal with those that do?" -Ensia



I**n Thailand,** Dr. Supaporn Wacharapluesadee is testing fruit bats and pigs with help from local experts & volunteers

A Never-Before-Seen Virus Has Been Detected in Myanmar's Bats

"The discovery of two new viruses related to those that cause SARS and MERS marks PREDICT's first milestone in the region" -Smithsonian Magazine

On TV

A PBS Special (check your local provider) on zoonotic viruses and the people working to prevent them from becoming pandemics featured PREDICT's Dr. Jonna Mazet and PREDICT partners.

Check your local television provider for the 3-part series #InvisibleKillers on the Discovery & Science Channels featuring PREDICT in Parts #1 Influenza & #2 Ebola.

Interntional Buzz

Journalists from The Telegraph UK joined PREDICT Sierra Leone team members in the field to learn more about PREDICT's mission to discover new viruses at high-risk interfaces.

The Telegraph

On the hunt for Disease X

The Guardian Nigeria recognizes the work of the Global Virome Project (GVP), including PREDICT's Dr. Jonna Mazet.

TheGuardian

ISTOÉ: Projeto quer identificar vírus que possam causar a próxima pandemia

Brazilian Magazine ISTOÉ recognizes PREDICT efforts and its international partners.

ISTOÉ

Tec Review Monterrey: Esta iniciativa busca 'cazar' virus para prevenir pandemia

Monterrey, Mexico based magazine also shines light on the hunt to prevent the next virus epidemic.

Tec Review

The Telegraph

Virus hunters identify two new pathogens in Myanmar -The Telegraph UK

scroll.in

The Scroll, India, Highlights the importance of a proactive approach to zoonotic outbreak research.

News and Radio

The Rescued Thai Soccer Team, Bats and USAID

The Thai government requested support from USAID/PREDICT's partner laboratory in Thailand to screen for viral pathogens in specimens from the soccer team.

M

USAID 2030 ENDING EXTREME POVERTY IN THIS GENERATION

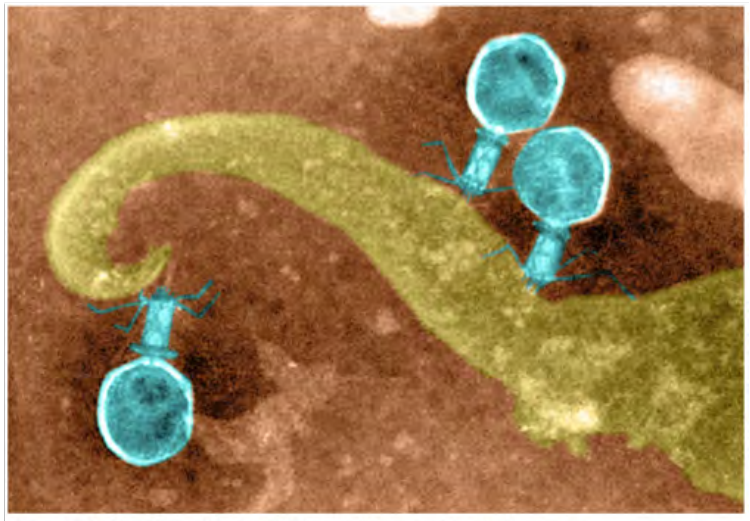
New SARS-Like virus discovered in Myanmar bats
Newsweek features the discovery of a novel SARS-Like virus in Wrinkle-lipped bats during PREDICT surveillance activities in Myanmar.

Scientists trying to understand Viruses before they become pandemics
PREDICT's Dr. Mazet sits down with KJZZ in Phoenix, USA to discuss identifying & preparing for viruses that could jump to humans.

Wired: The Race to Find the Next Pandemic – Before it Finds Us
In Southern China, PREDICT & EcoHealth Alliance helped identify the mysterious cause of piglet deaths.

WIRED

New York Times: Trillions upon trillions of Viruses fall from the sky each day
PREDICT's Dr. Peter Daszak speaks with the New York Times about the ecological effects of viral infections.



Viruses attached to a fragment of a bacterial cell wall. "Viruses modulate the function and evolution of all living things," scientists wrote last year. "But to what extent remains a mystery."
Biophoto Associates/Science Source

The Atlantic: Is It Possible to Predict the Next Pandemic?
The Atlantic spotlights the Global Virome Project (GVP).

Stay up to date with PREDICT on Healthmap

HealthMap
Global Health, Local Information

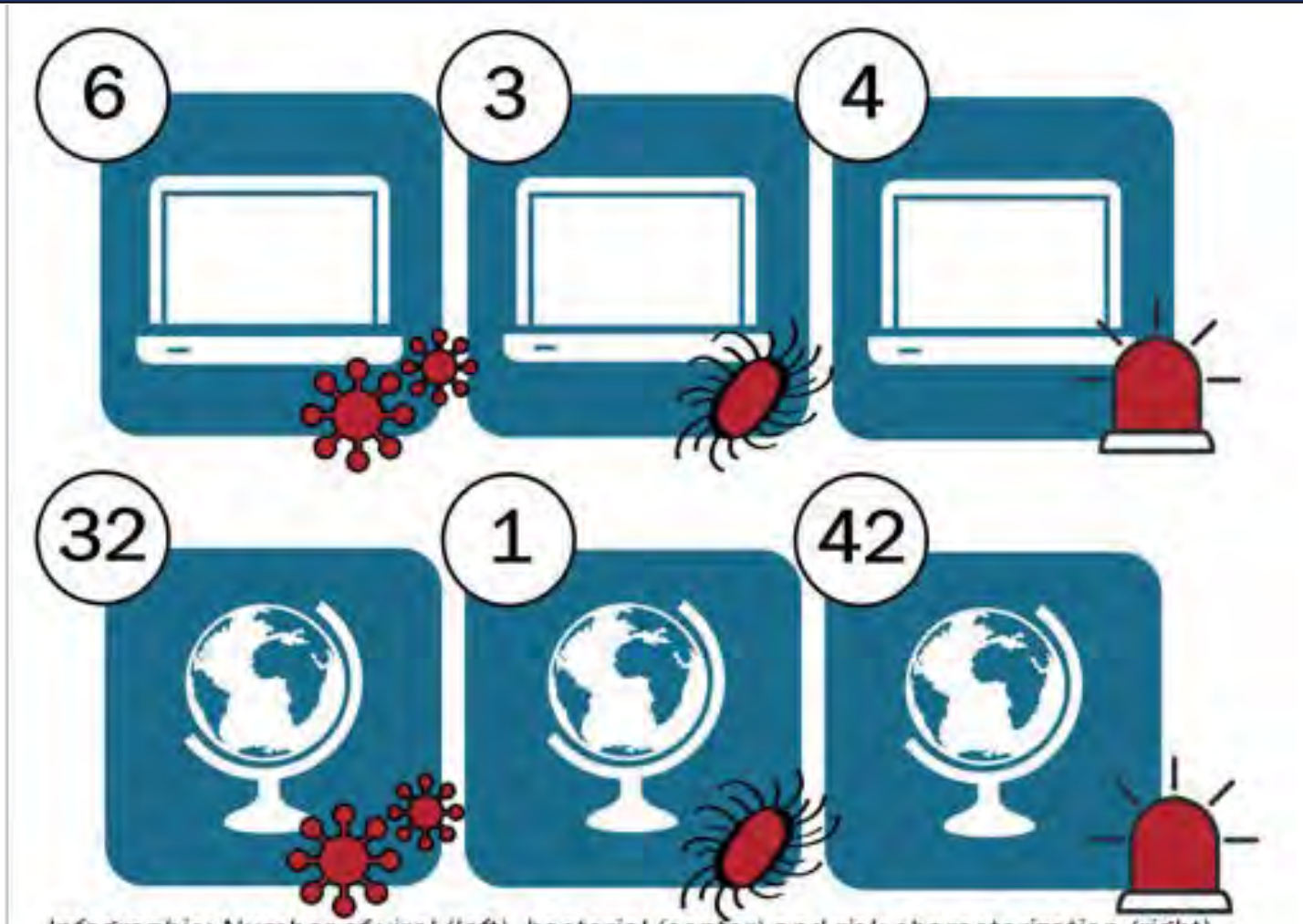
Coming Soon

TEDMED: The Hive
Each year TEDMED celebrates the ideas behind progress in health & medicine. In November, PREDICT's Dr. Jonna Mazet will participate in The Hive, and present about PREDICT and GVP in a live TEDMED: Chaos and Clarity event November 14-16.

Photo: PREDICT/Tanzania

VI. APPENDICES

PREDICT Year 4 Annual M&E
M&E 1.1b Maps & Models



Infographic: Number of viral (left), bacterial (center) and risk characterization (right) models (top) and maps (bottom) developed or refined between 10/1/17 - 9/30/18.

USAID
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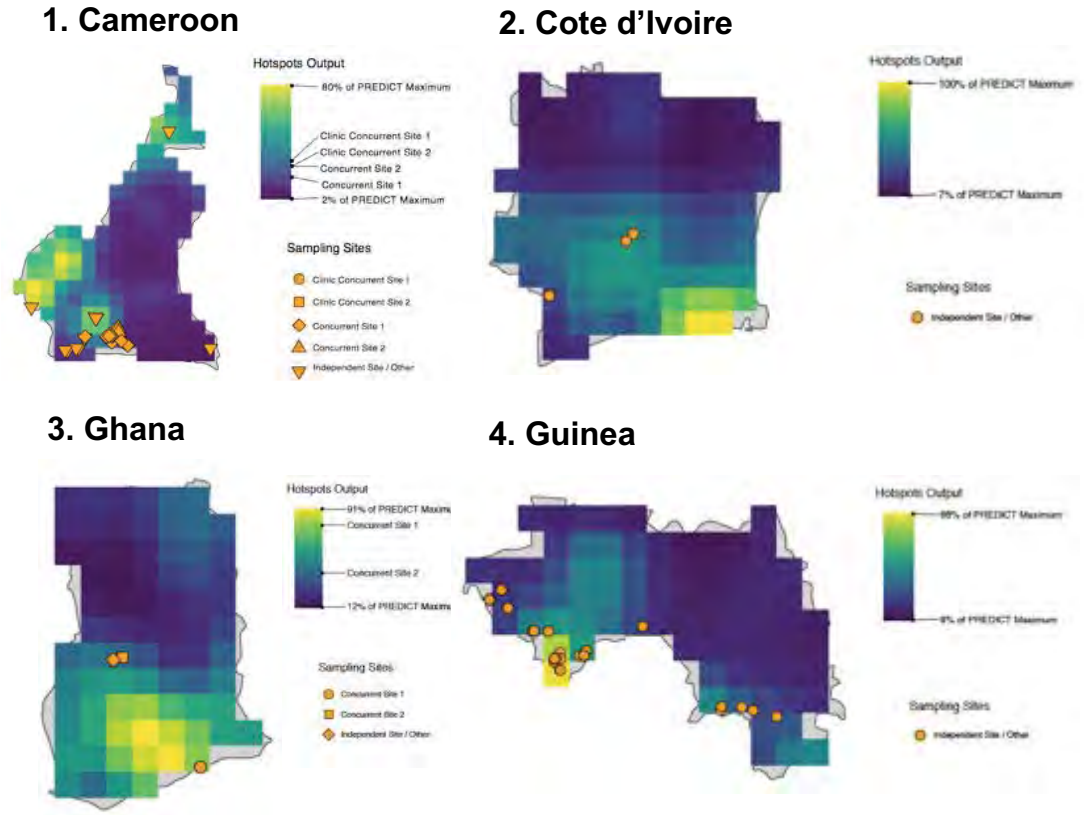
Emerging Threats Program 2 (EPT-2)

1-4 West Africa Country-level zoonotic virus spillover risk maps

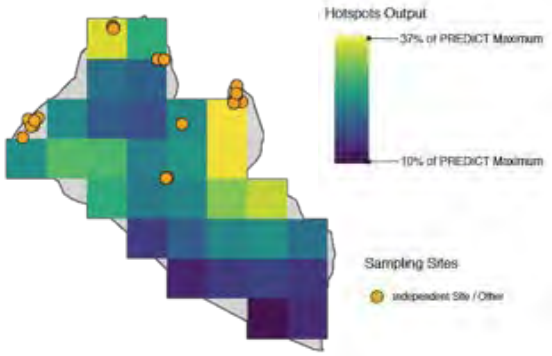


1-30. Country level zoonotic virus spillover maps. For PREDICT's All-country meeting in Brussels, Belgium in January 2018, we created country-specific relative spatial risk maps of novel zoonotic viral spillover, based on the PREDICT Hotspots 2.0 model, a global model fit to 224 new disease emergence events reported globally.

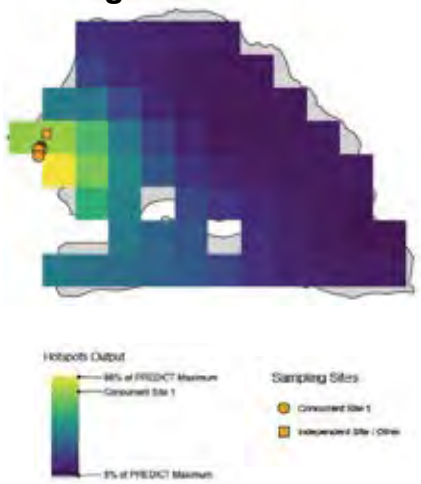
5-7 West Africa

Country-level zoonotic virus spillover risk maps

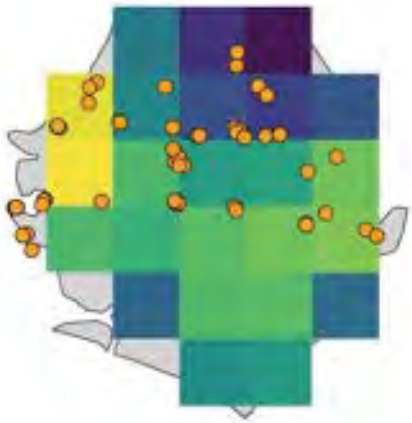
5. Liberia



6. Senegal



7. Sierra Leone



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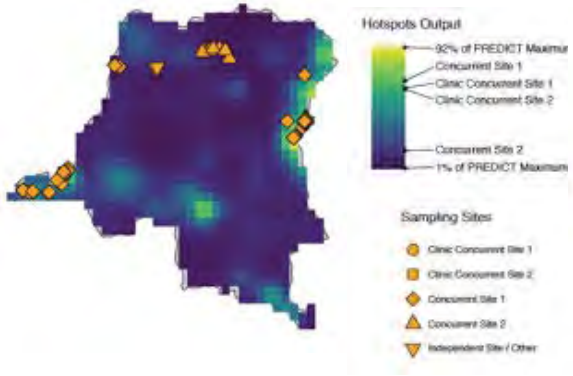
Emerging Threats Program 2 (EPT-2)

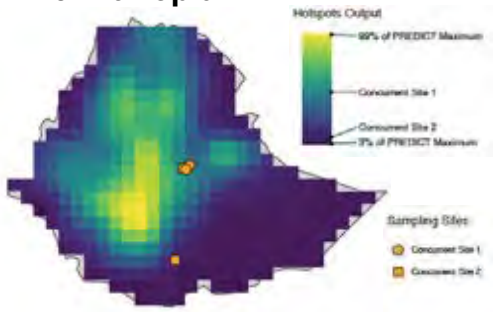
8-11 East & Central Africa

Country-level zoonotic virus spillover risk maps

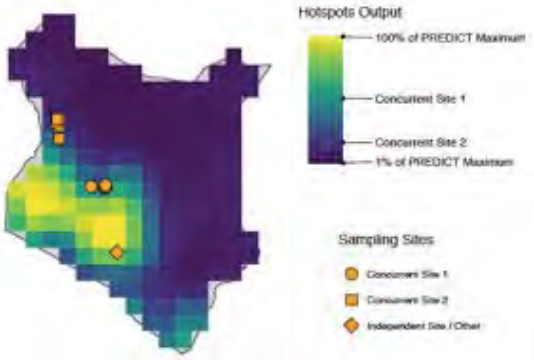
8. Democratic Republic of Congo



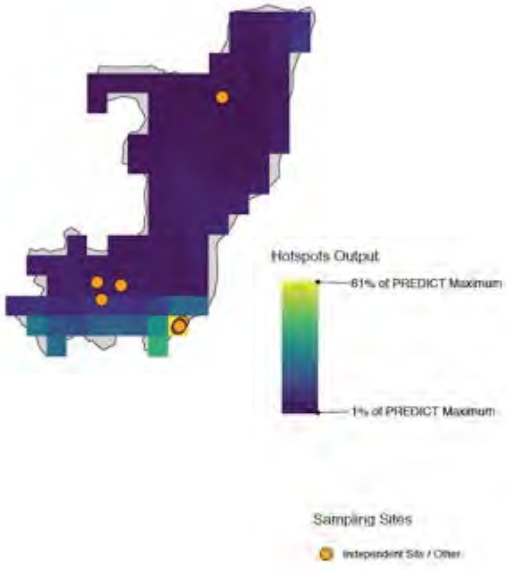
9. Ethiopia



10. Kenya



11. Republic of Congo



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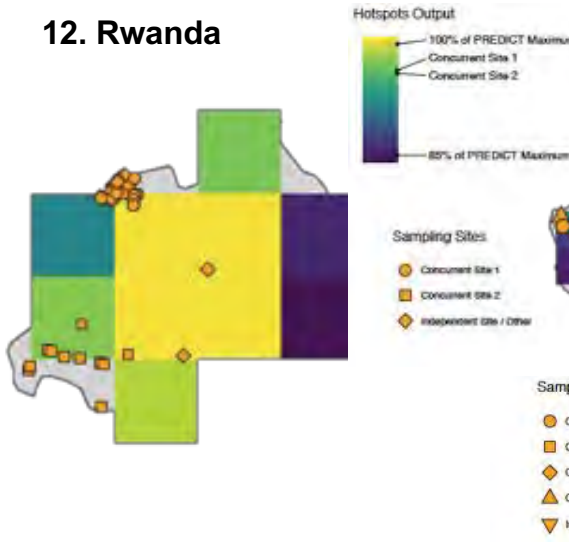
Emerging Threats Program 2 (EPT-2)

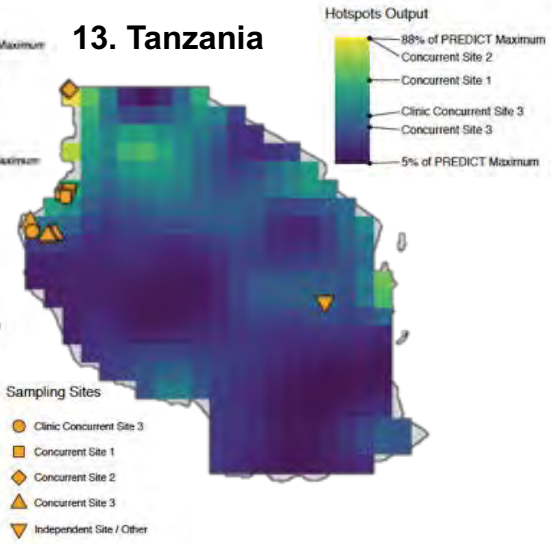
12-14 East & Central Africa

Country-level zoonotic virus spillover risk maps

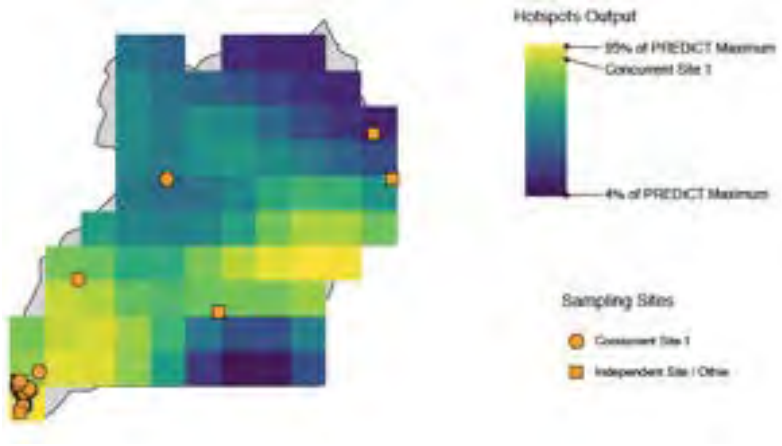
12. Rwanda



13. Tanzania



14. Uganda



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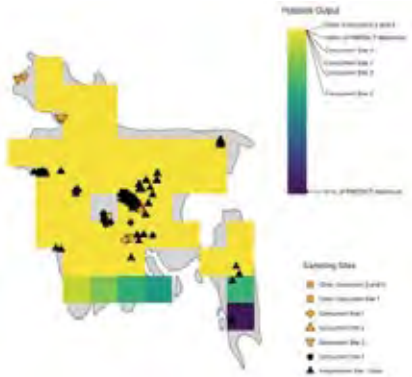
Emerging Threats Program 2 (EPT-2)

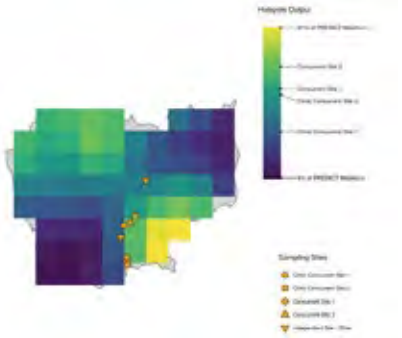
15-18 Asia

Country-level zoonotic virus spillover risk maps

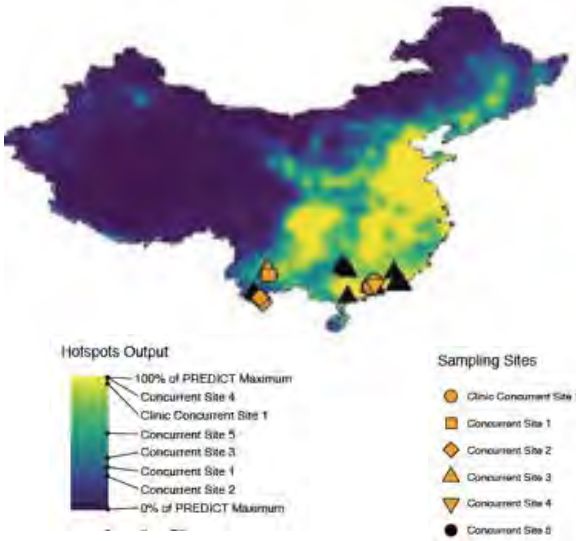
15. Bangladesh



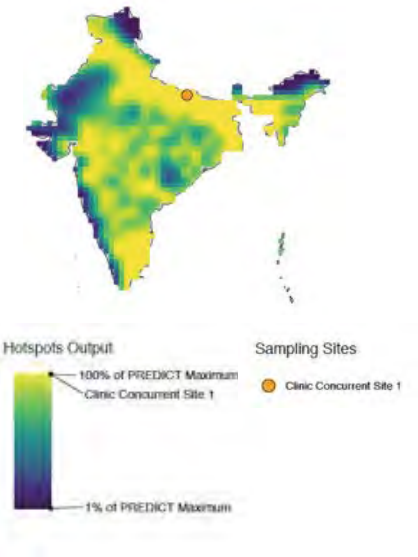
16. Cambodia



17. China



18. India



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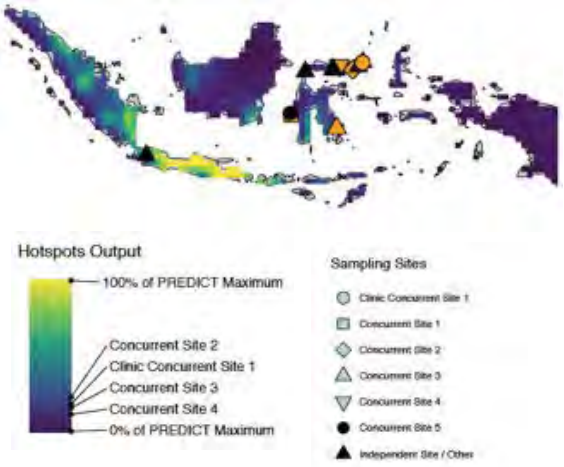
Emerging Threats Program 2 (EPT-2)

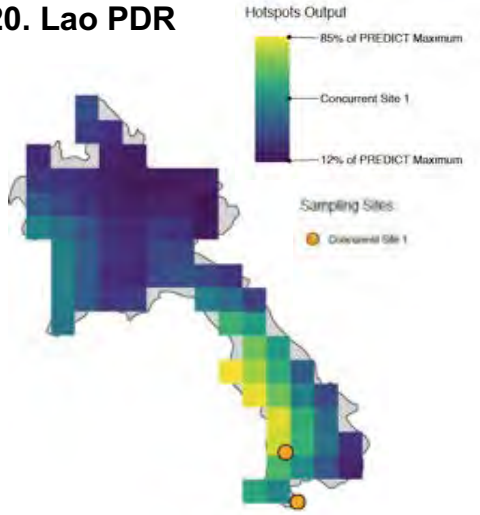
19-22 Asia

Country-level zoonotic virus spillover risk maps

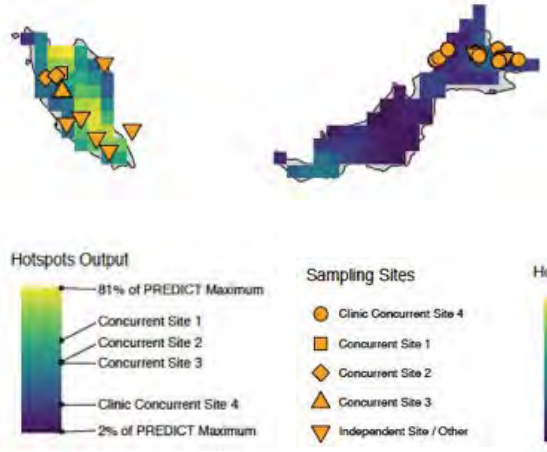
19. Indonesia



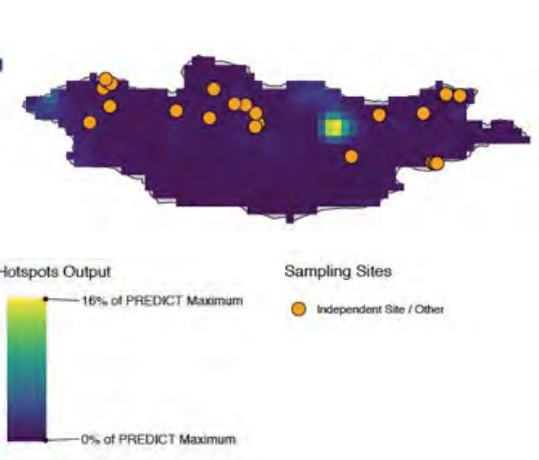
20. Lao PDR



21. Malaysia



22. Mongolia



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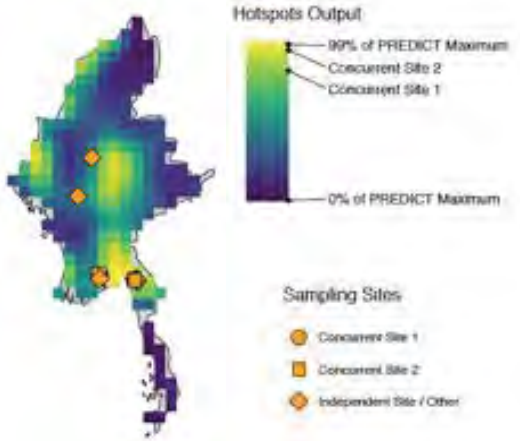
Emerging Threats Program 2 (EPT-2)

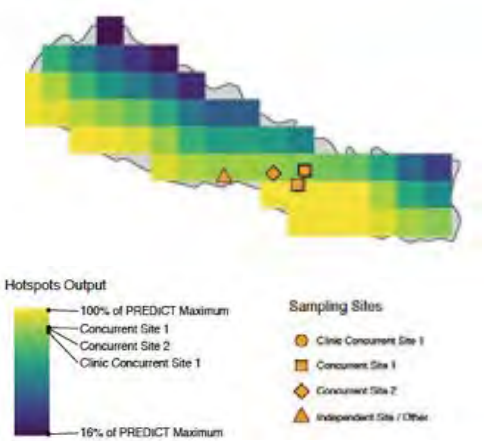
23-26 Asia

Country-level zoonotic virus spillover risk maps

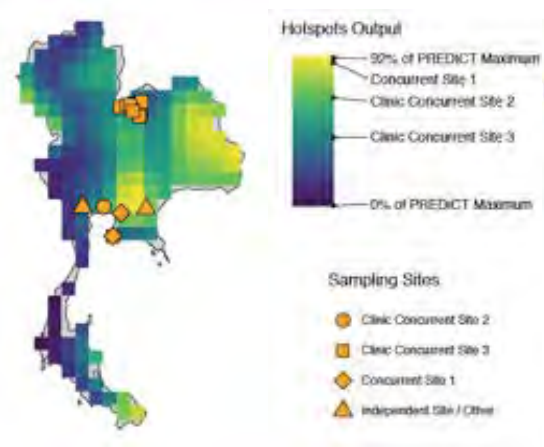
23. Myanmar



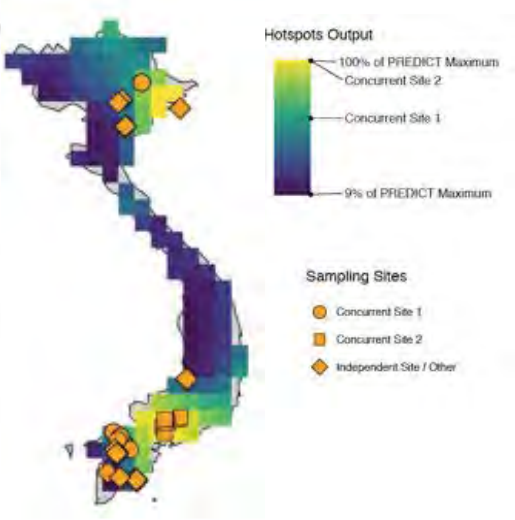
24. Nepal



25. Thailand



26. Vietnam



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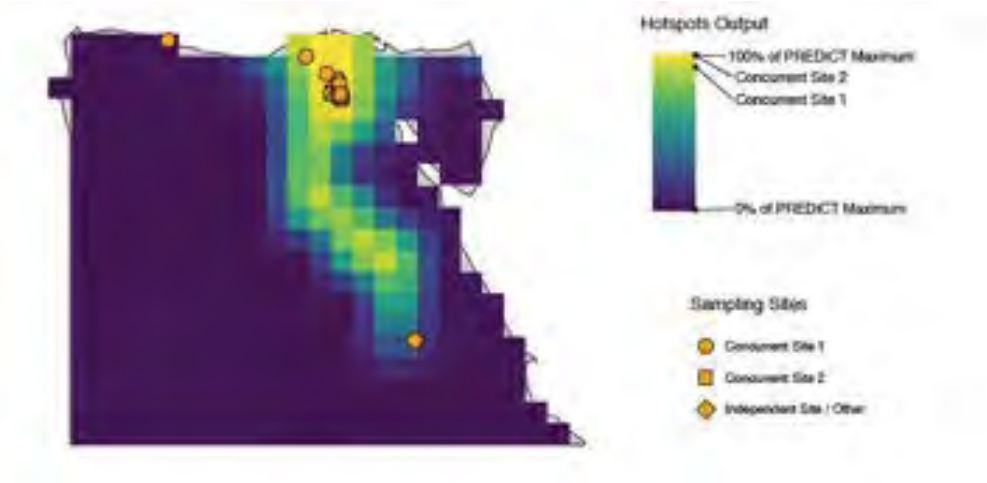
Emerging Threats Program 2 (EPT-2)

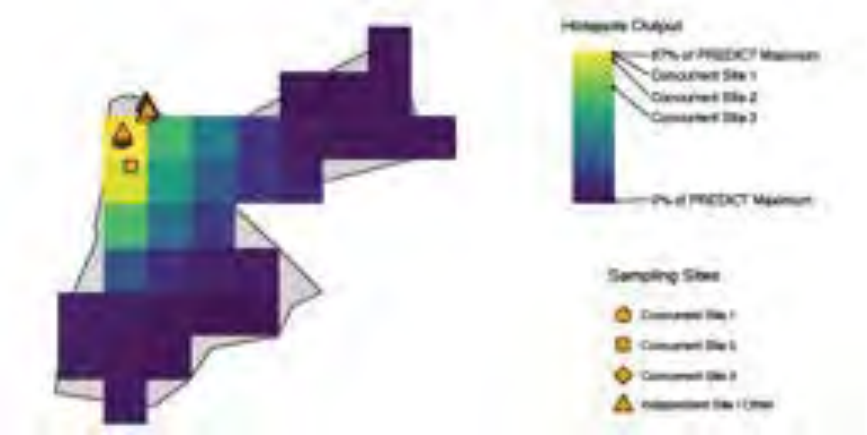
27-28 Middle East

Country-level zoonotic virus spillover risk maps

27. Egypt



28. Jordan



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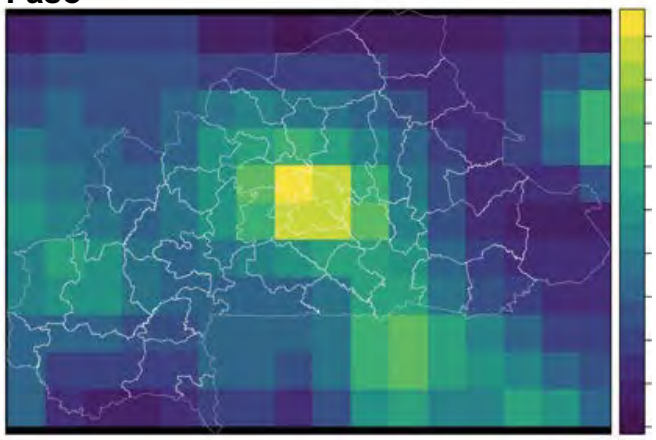
Emerging Threats Program 2 (EPT-2)

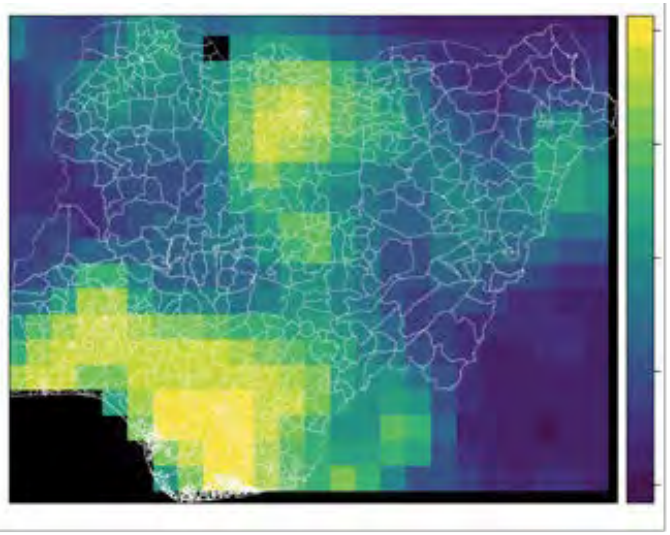
29-30 ASL2050 Countries

Country-level zoonotic virus spillover risk maps

29. Burkina Faso

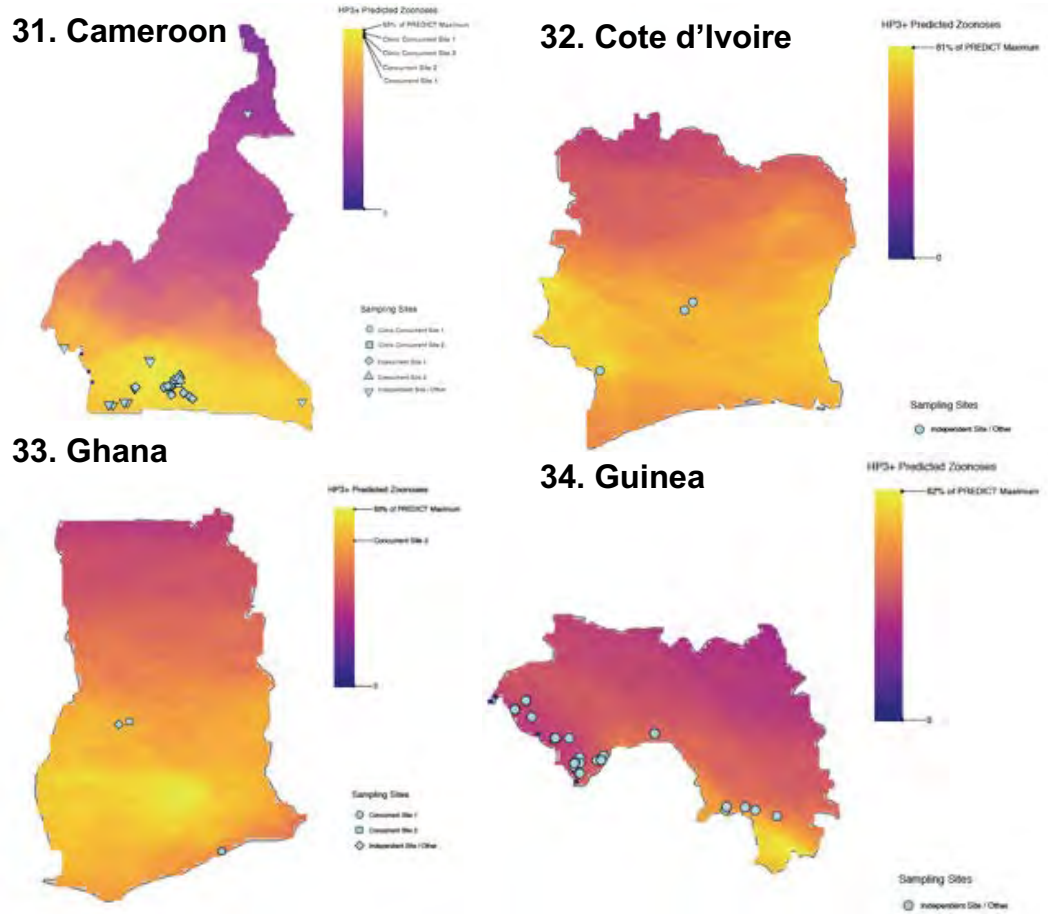


30. Nigeria



31-34 West Africa

Predicted zoonotic diversity risk maps



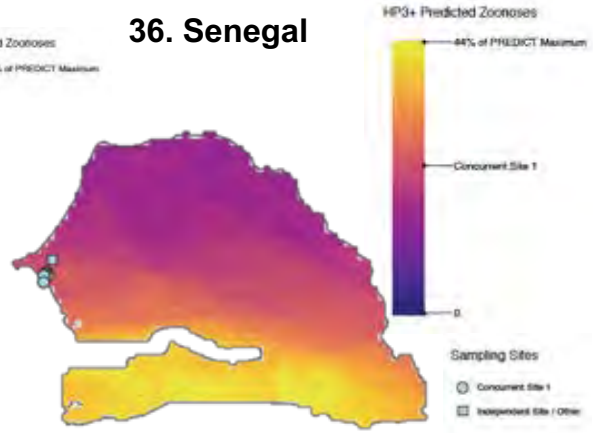
31-58. Country-level predicted zoonotic diversity risk maps. For the PREDICT All-country meeting in Brussels, we created per-country distribution maps of predicted total diversity potential of zoonotic viruses within mammals, based on Olival et al. 2017.

35-37 West Africa

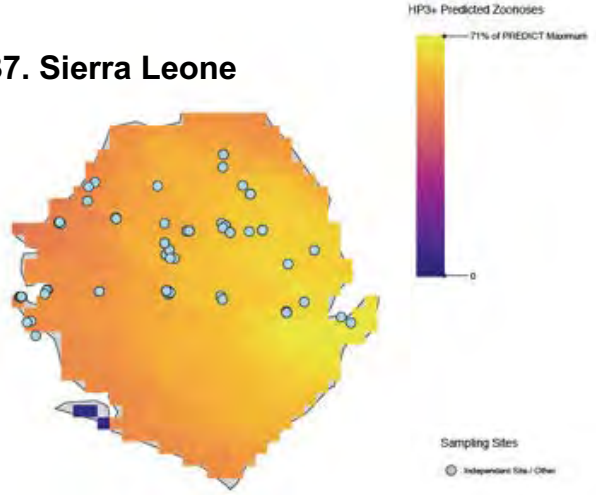
Predicted zoonotic diversity risk maps

35. Liberia

36. Senegal



37. Sierra Leone



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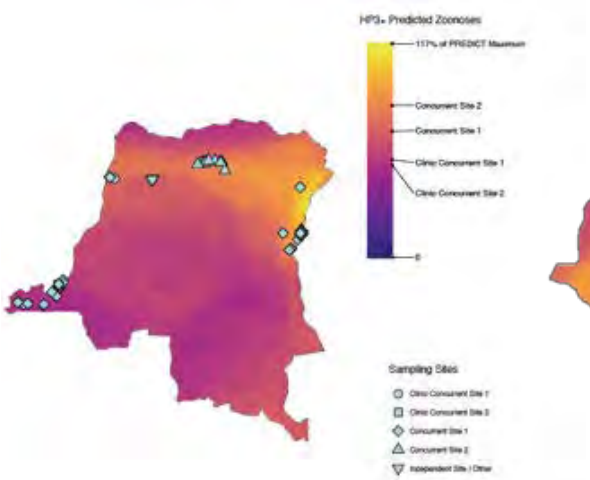
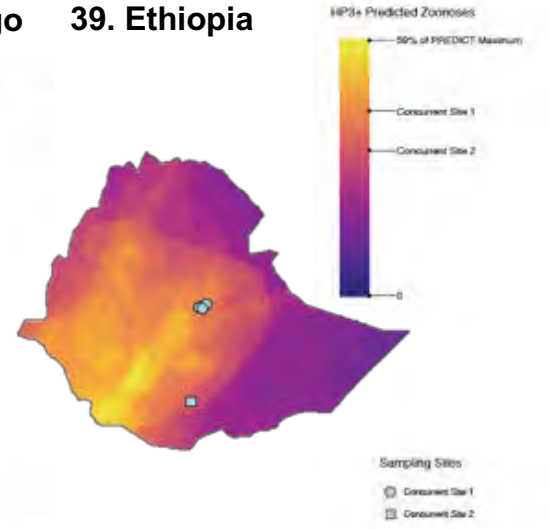
Emerging Threats Program 2 (EPT-2)

38-41 East & Central Africa Predicted zoonotic diversity risk maps

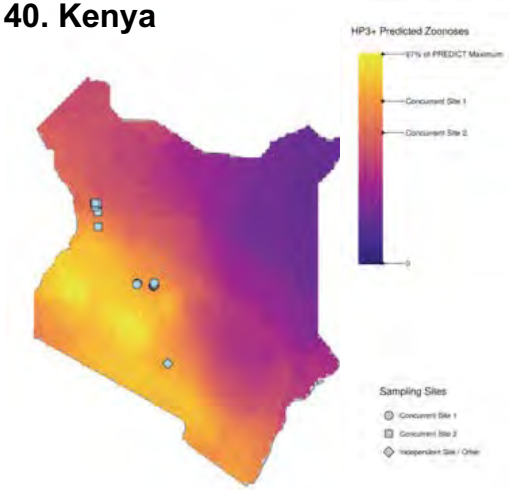
38. Democratic Republic of Congo



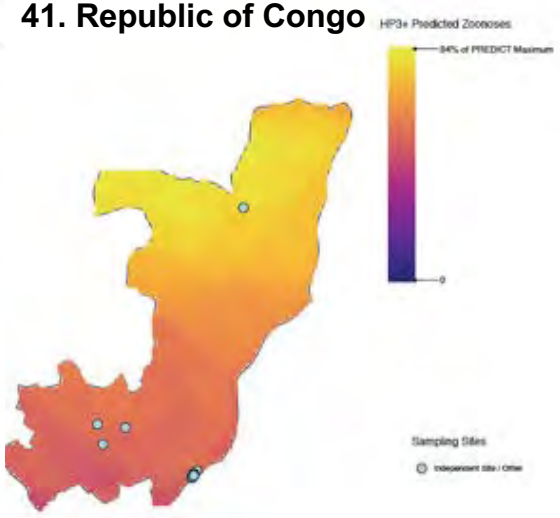
39. Ethiopia



40. Kenya



41. Republic of Congo



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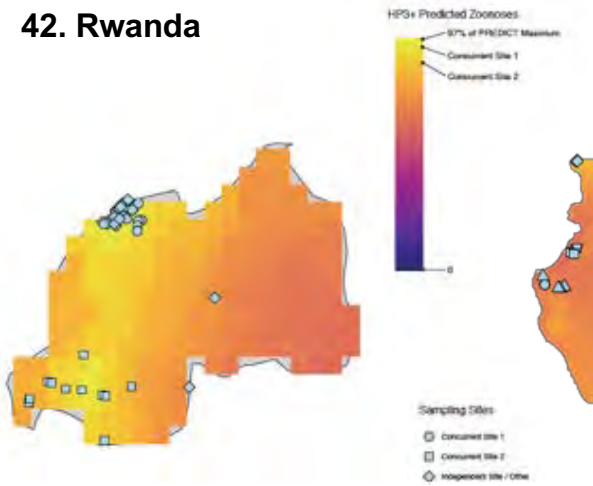
Emerging Threats Program 2 (EPT-2)

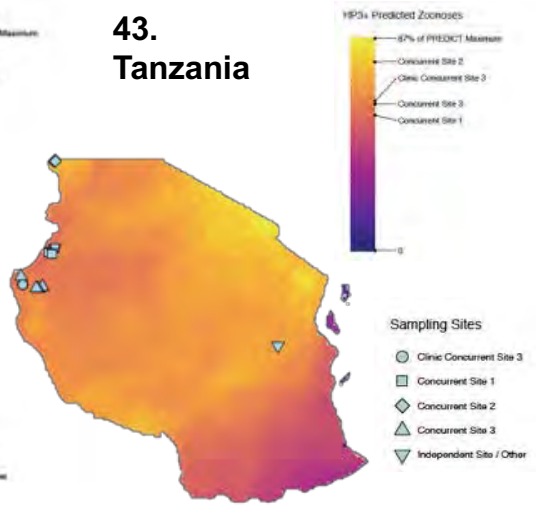
42-44 East & Central Africa

Country-level predicted zoonoses maps

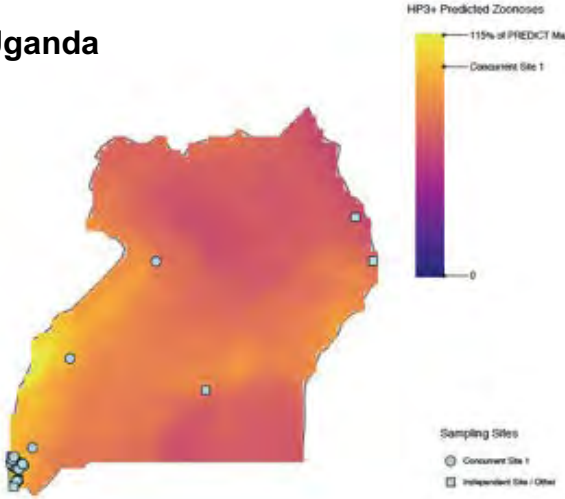
42. Rwanda



43. Tanzania



44. Uganda



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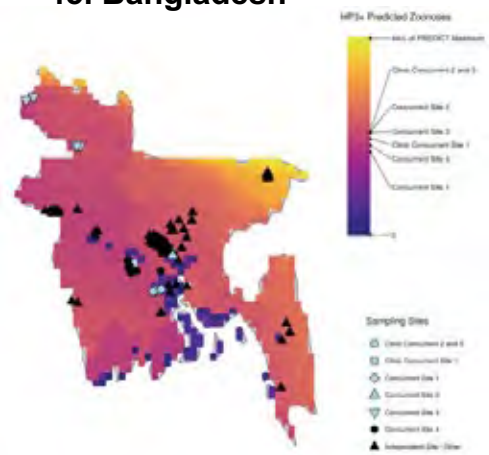
Emerging Threats Program 2 (EPT-2)

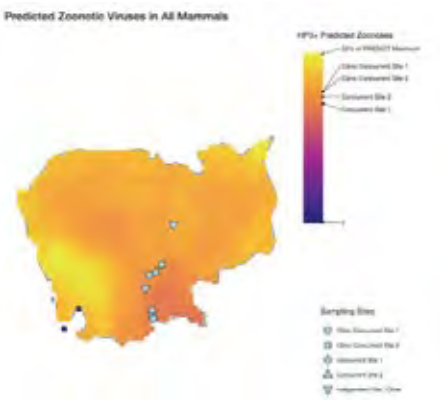
45-48 Asia

Country-level predicted zoonoses maps

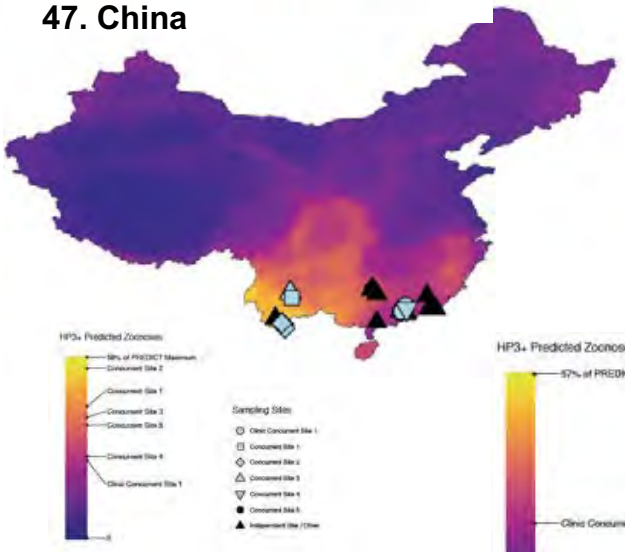
45. Bangladesh



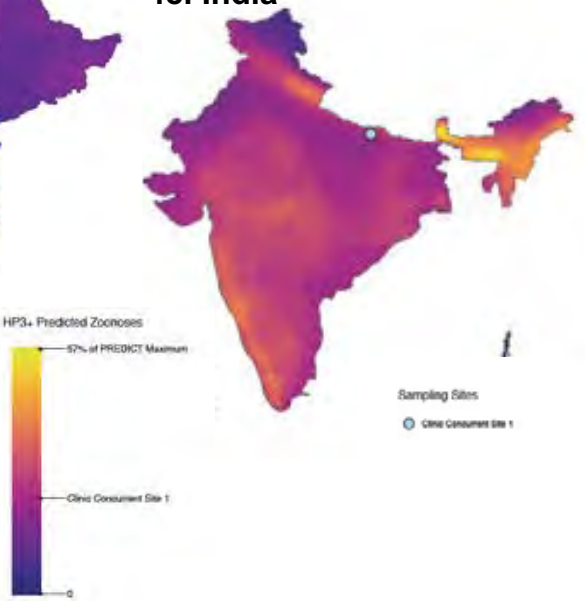
46. Cambodia



47. China



48. India



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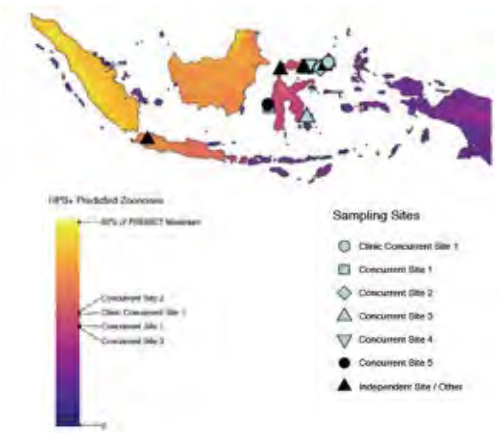
Emerging Threats Program 2 (EPT-2)

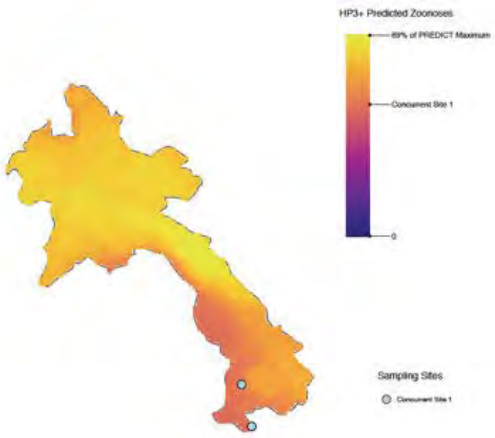
49-52 Asia

Predicted zoonotic diversity risk maps

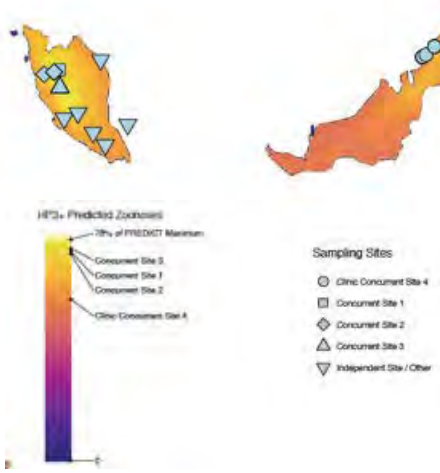
49. Indonesia



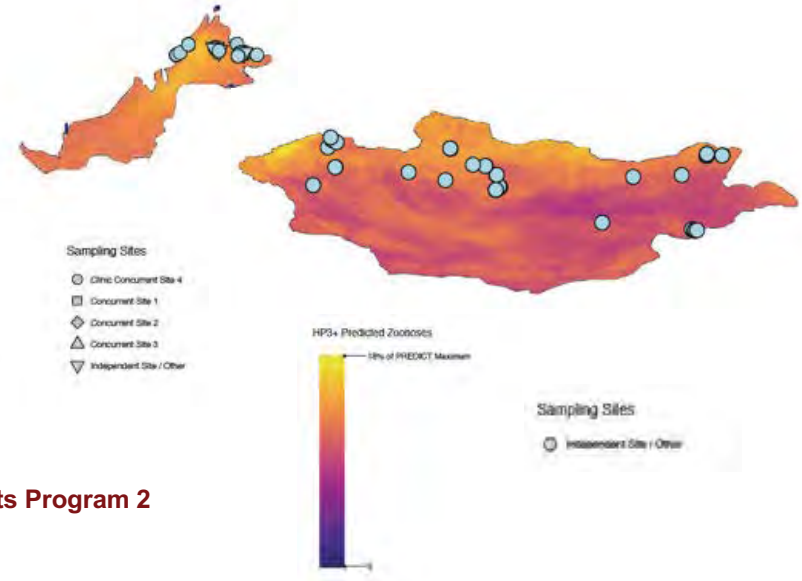
50. Lao PDR



51. Malaysia



52. Mongolia



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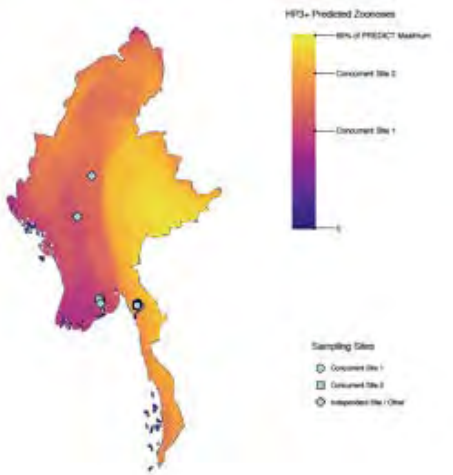
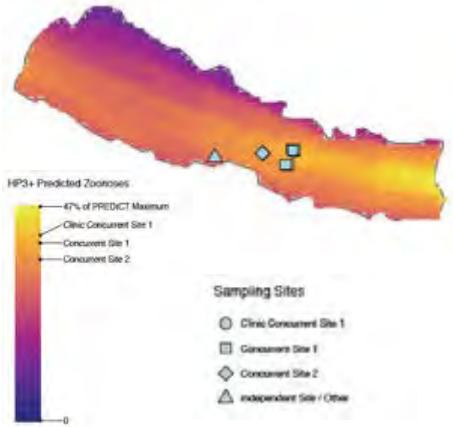
Emerging Threats Program 2 (EPT-2)

Predicted zoonotic diversity risk maps

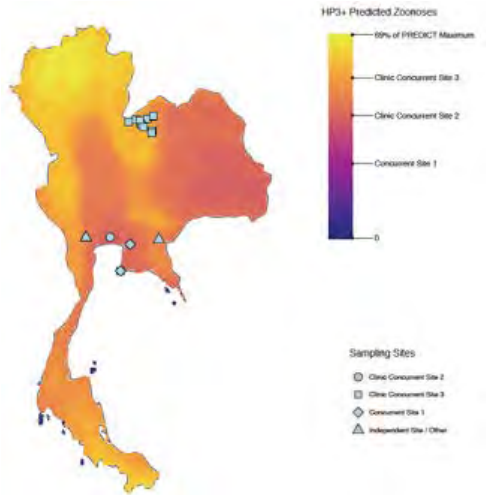
53. Myanmar



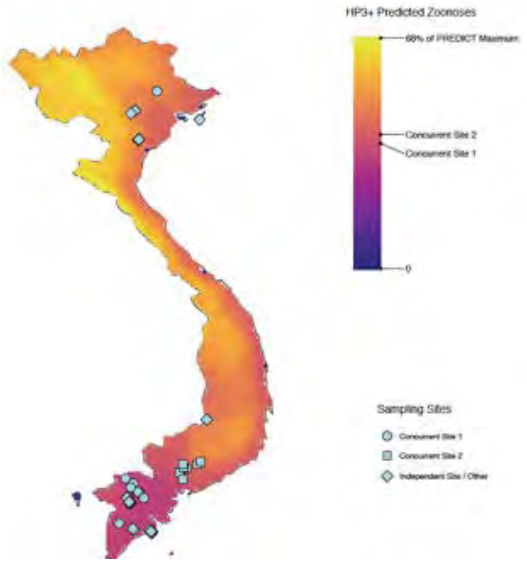
54. Nepal



55. Thailand



56. Vietnam



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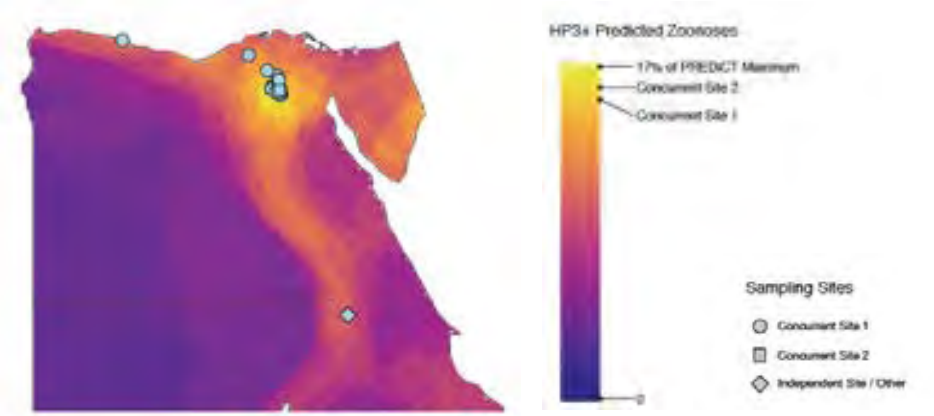
Emerging Threats Program 2 (EPT-2)

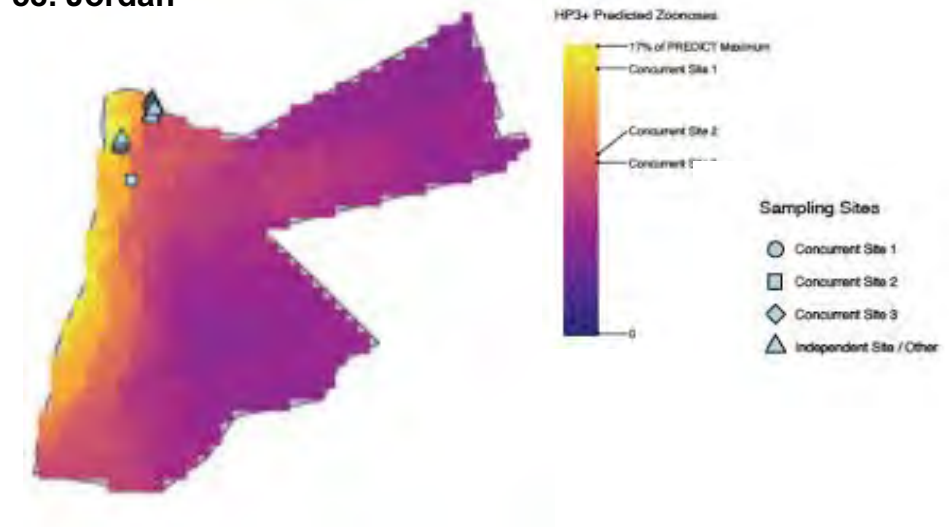
57-58 Middle East

Predicted zoonotic diversity risk maps

57. Egypt



58. Jordan



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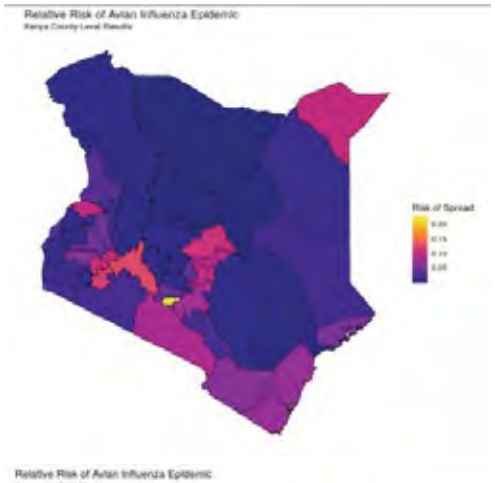
Emerging Threats Program 2 (EPT-2)

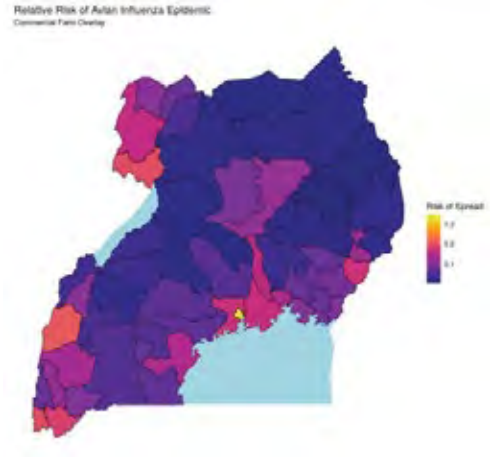
59-62 ASL2050 Countries

Avian Influenza Spread Risk Maps

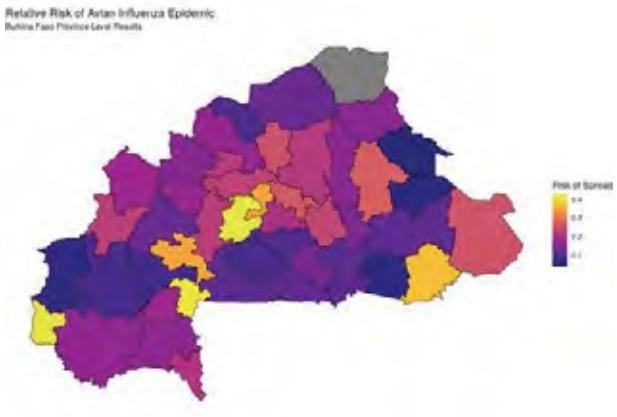
59. Kenya



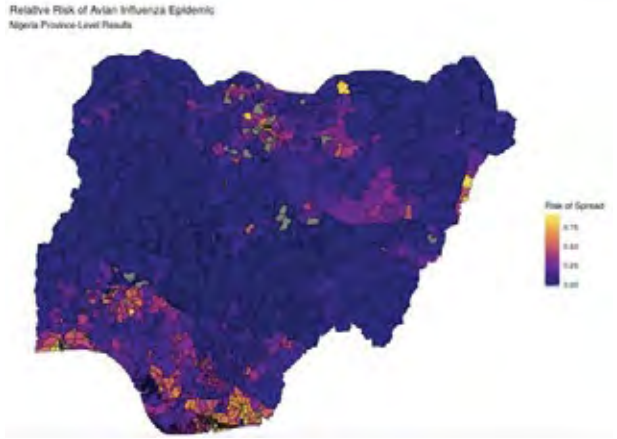
60. Uganda



61. Burkina Faso



62. Nigeria



59-62. Province-level avian influenza epidemic risk maps. We continued to develop our metapopulation model to assess potential spread of avian influenza based on large-scale networks of interconnected household, market, and commercial farm poultry flocks for ASL2050 countries.

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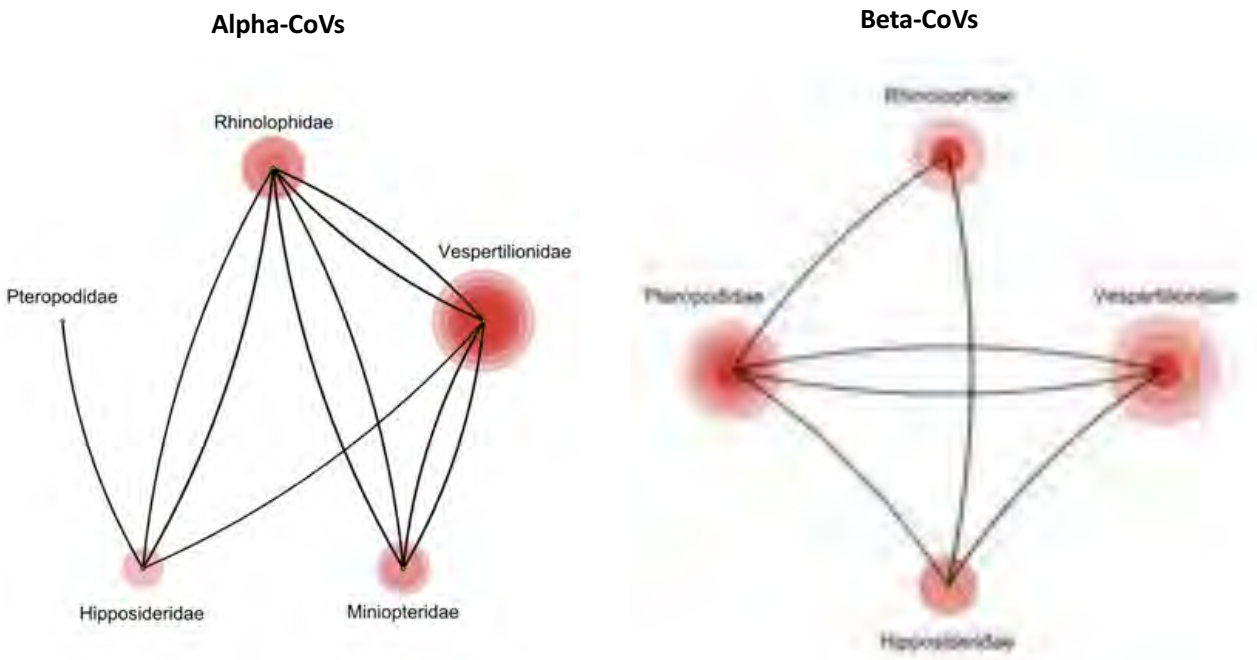
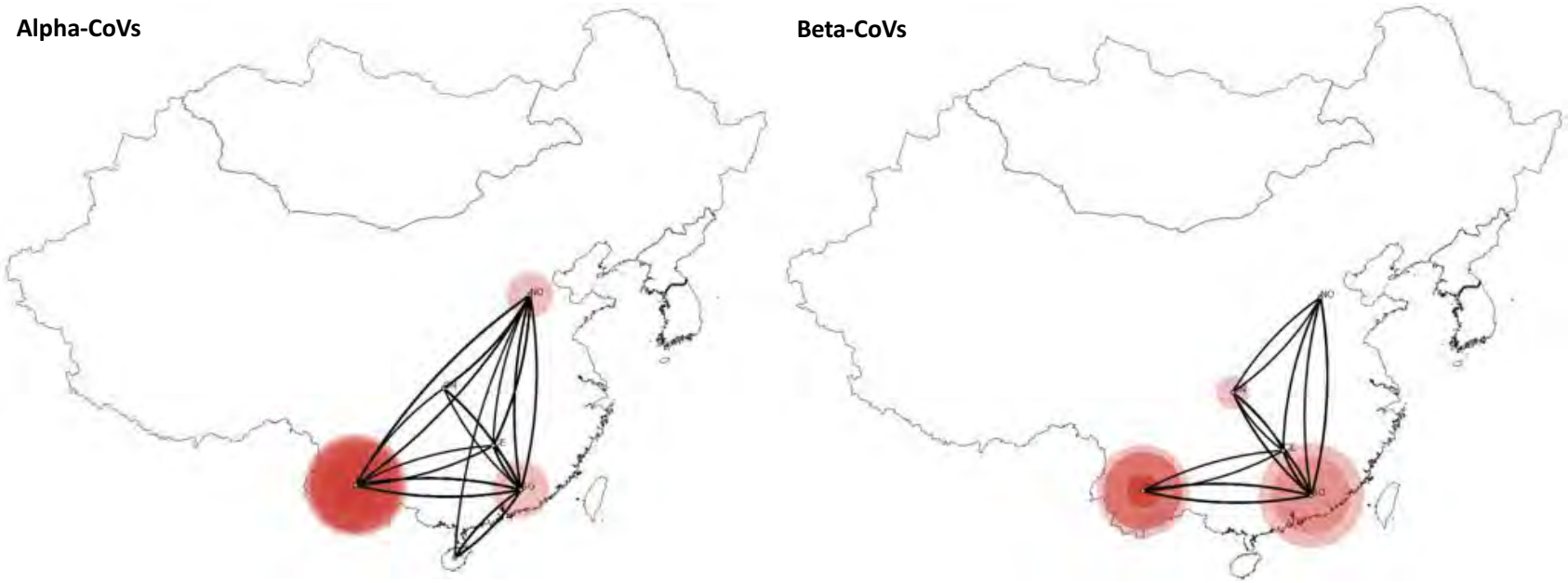
Emerging Threats Program 2 (EPT-2)

Origin of coronaviruses



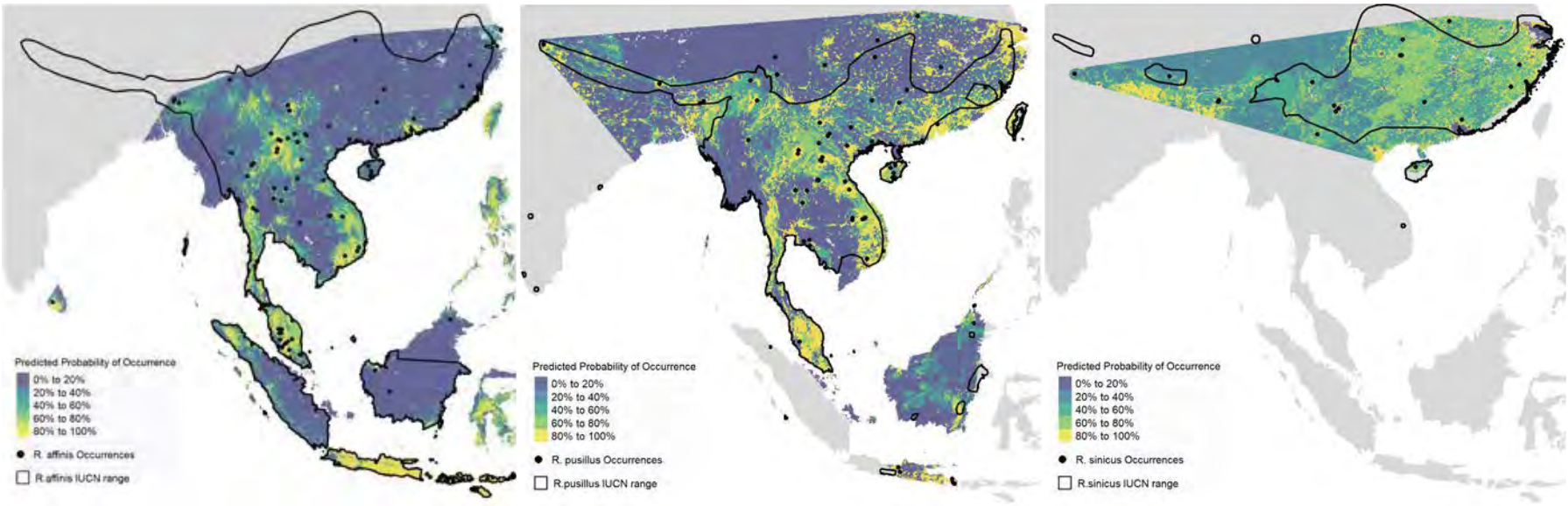
63-64. Origin and cross-species transmission of bat coronaviruses in China. We reconstruct the ancestral hosts for each node in the phylogenetic trees of Alpha- and Beta-CoVs using a Bayesian phylogeographic approach. The black lines represent branches of the phylogenetic tree connecting different host transitions (or historical host switching events). Circle size is proportional to the number of branches that have each bat family as an ancestor at different time periods. Vespertilionidae and Rhinolophidae are the evolutionary sources of Alpha-CoVs, Vespertilionidae and Pteropodidae are the evolutionary sources of Beta-CoVs.

Origin of coronaviruses



65-66. Origin and cross-species transmission of bat coronaviruses in China. We reconstruct the ancestral locations of origins (centers of evolution) for each node in the phylogenetic trees of Alpha- and Beta-CoVs using a Bayesian phylogeographic approach. Southwestern and Southern China are the evolutionary hotspots of Alpha- and Beta-CoVs, respectively.

67-69 Asia IMPACT Project: Regional Risk of a Bat-Pig Outbreak



67-69. Species distribution models of 3 bat species thought to be the origin of SADS coronavirus. Severe Acute Diarrheal Syndrome (SADS) Coronavirus that killed over 20,000 pigs in an outbreak in China in 2017-18, is found naturally in *Rhinolophus spp.* bats. To better understand the potential for future SADS-CoV outbreaks from these bat hosts in the region, we modeled the distributions of 3 key *Rhinolophus* SADS-CoV host species across their range. Species distribution models for *R. affinis, R. pusillus, R. sinicus* (left to right) in South China and Southeast Asia are pictured with IUCN ranges (black outline) and species occurrence (black dots).

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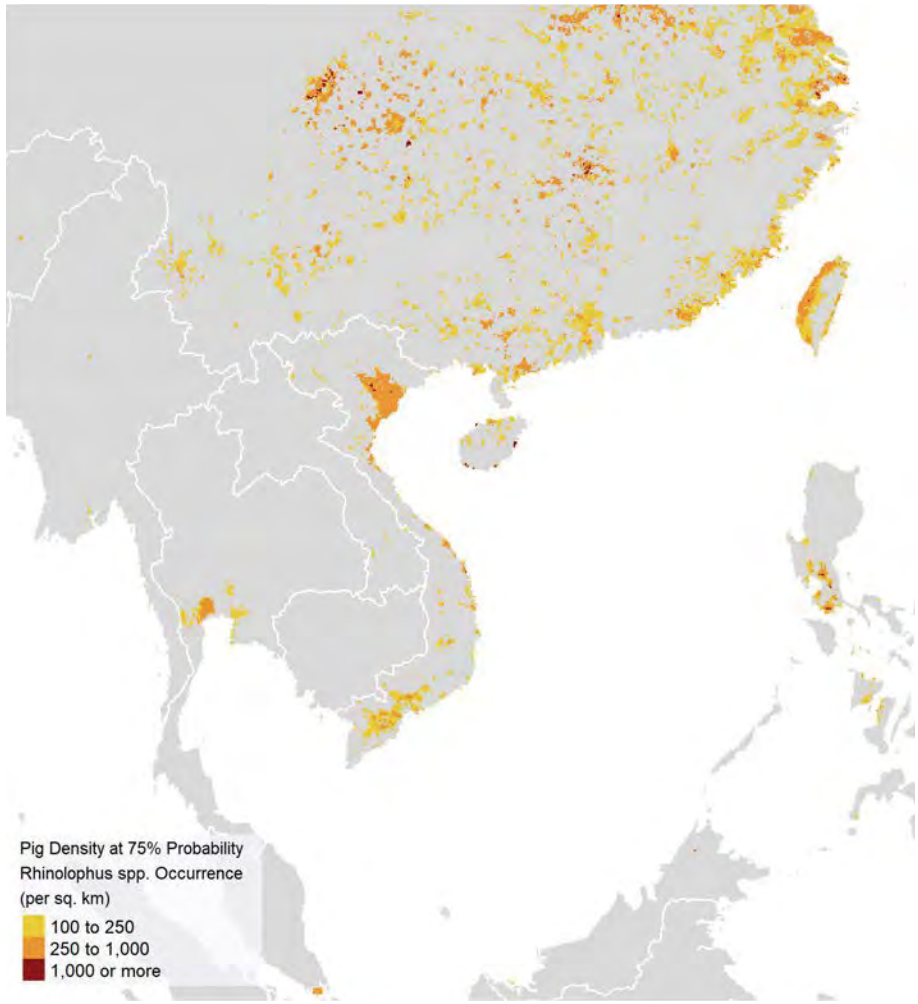
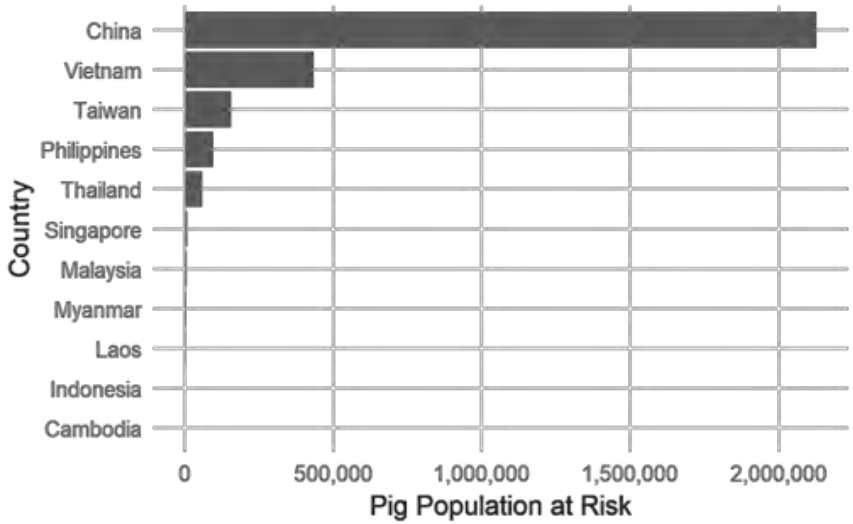
70-71 Asia IMPACT Project: Regional Risk of a Bat-Pig Outbreak





70-71. Areas of highest bat-pig overlap. Areas of bat-pig overlap where probability of SADS-CoV *Rhinolophus spp.* host occurrence is high (>75%) and pig densities are indicative of intensive pig farming (>100 heads per km^2). We find that pig populations within areas of predicted *Rhinolophus spp.* occurrence (pig population at risk) are concentrated in regions scattered across China, with additional areas of risk in Vietnam, Taiwan, and Thailand.

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72 China IMPACT Project: Regional Risk of a Bat-Pig Outbreak

72. Pig Population at risk within China. Pig populations that overlap with the 3 *Rhinolophus spp.* bats are localized to southern China, where pig farming is the most intensive. Sichuan and Jiangsu provinces have the most pigs at risk (>200,000 heads).

73 Myanmar

IMPACT Project: Bat-Palm Sap Overlap

73. Locations of palm sap-fruit bat interfaces in Yangon Province, Myanmar. The intersection of fruit bat populations with palm sap collection and consumption is a known risk factor for the emergence of Nipah virus in Bangladesh. To investigate if this disease interface exists across a broader region, including neighboring Myanmar, PREDICT is collecting and intersecting data on locations of palm sap and wine production, the harvesting and consumption practices of palm sap and palm wine drinkers, and the extent of overlap with fruit bats. These data will inform provinces and sites that should be targeted for increased disease surveillance.

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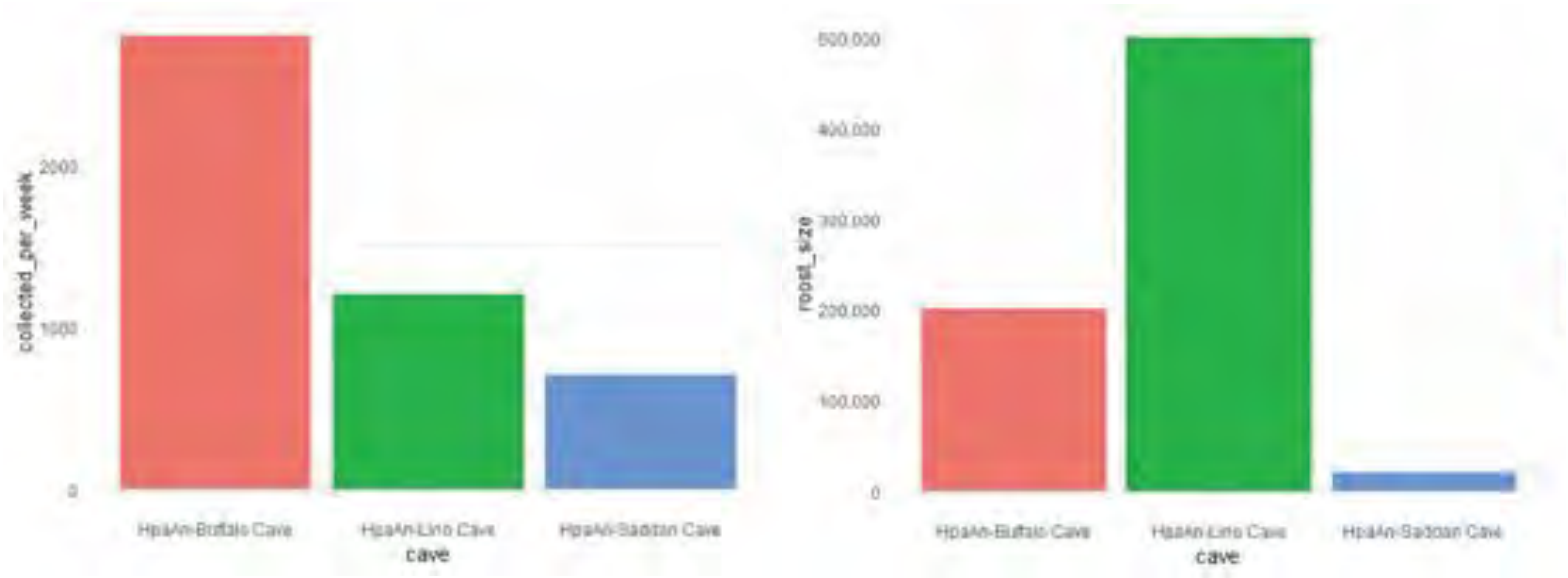
IMPACT Project: Bat-Harvester Interactions



74-75. Bat-Harvester interactions at cave sites. This ongoing IMPACT project examines the difference in risk between cave and farm guano collection sites. Preliminary data for estimates of bat and guano contact are shown above for PREDICT sites in Myanmar: kilograms of guano collected (left) and bat roost size within caves (right).

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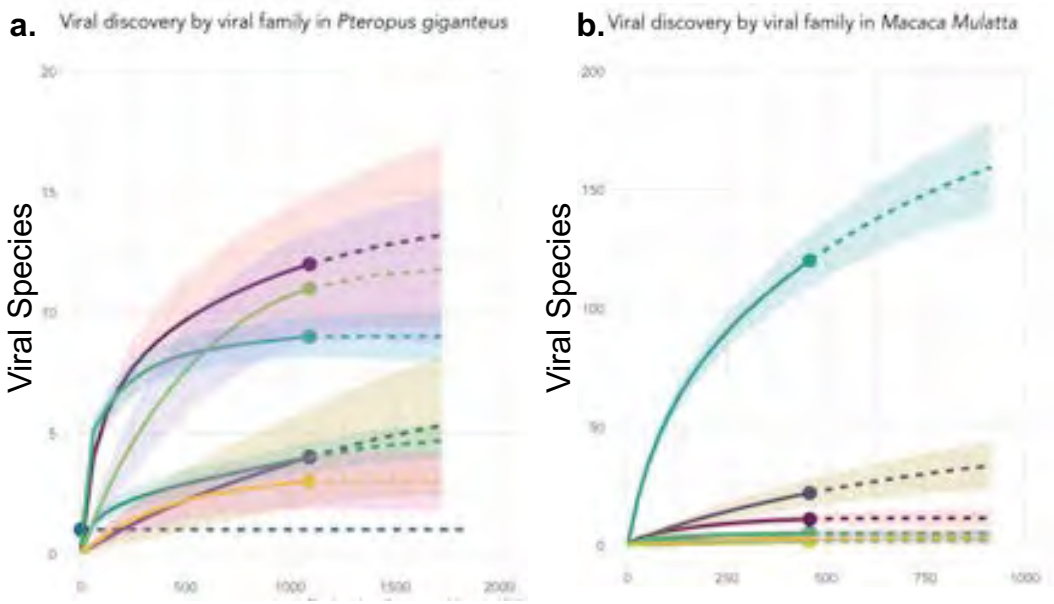
Viral accumulation curves by viral family



76-77. Viral species accumulation per viral family. To estimate the number of potentially zoonotic unknown viruses for the Global Virome Project (per Carroll *et al*. 2018, *Science*), we constructed viral accumulation curves using underlying data from **a)** Anthony *et al*. 2013 and **b)** Anthony *et al*. 2015. We found a per-viral family mean of 11.58 unknown species per family, and extrapolated this to 25 viral families that contain viruses known to infect people, to estimate 1.67 million unknown viruses in mammals and birds.

78 Thailand

Prioritizing Viral Sampling Sites

78. Delineating priority sampling sites for virus identification in mammal species. Using Thailand as a pilot study, the PREDICT M&A team supported the Global Virome Project in designing an optimal site selection strategy. Using "Zonation", a spatial planning decision support tool, we identified sites for sampling that yield the highest rate of viral discovery in mammals at the lowest cost (based on cost of access) at a 10 km scale. The graphic at left depicts sampling sites that were selected in more than half of the model runs (green) overlaid with protected areas in Thailand (red).

79 Global

Wild mammal species richness map

79. Global distribution of wild mammals in PREDICT countries. As part of the country reports presented at the PREDICT All-country meeting in Brussels in January, we created an updated map of wild mammal diversity, one of the most important predictors of zoonotic disease risk and of the number of zoonotic viruses likely to be found in a location. Using this global map based on IUCN data, we produced maps for 28 PREDICT countries, additionally calculating per-country species richness for bats, rats, and primates.

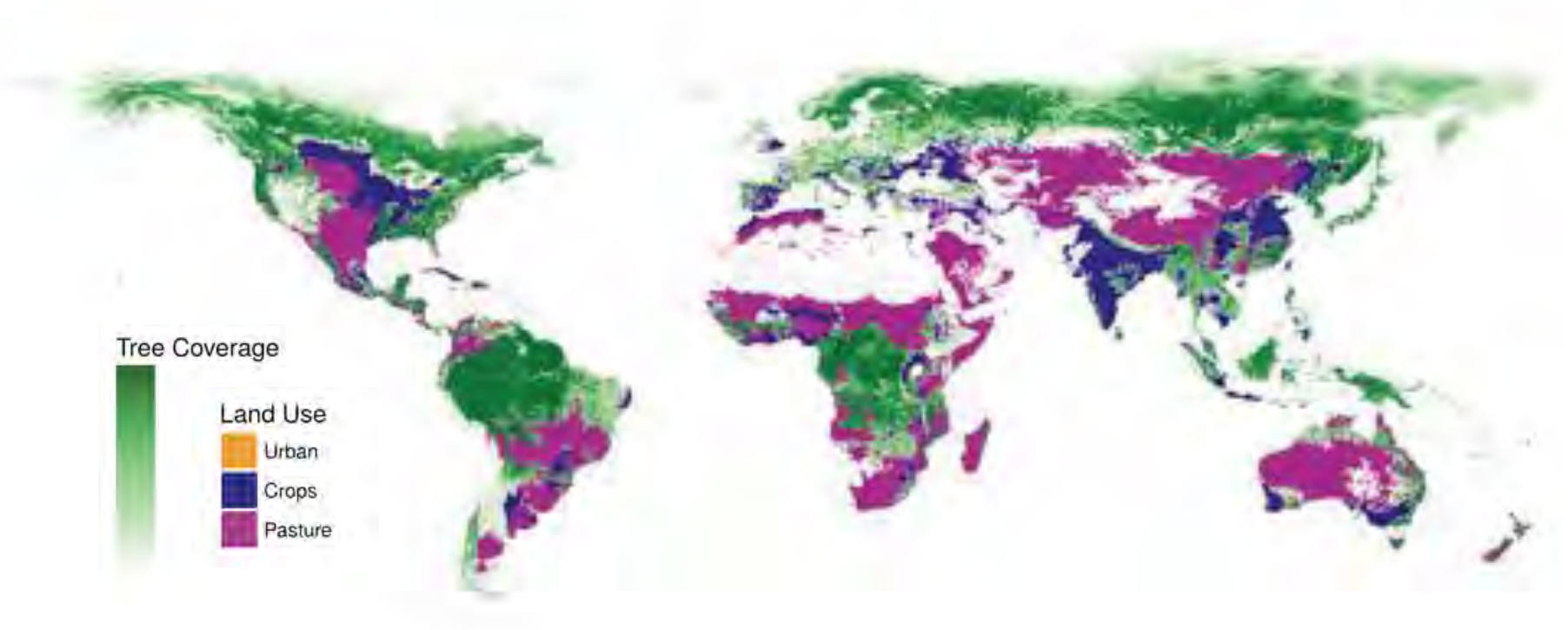
80 Global

Domestic animal density map

80. Aggregated global mammalian livestock density. For the PREDICT All-country meeting in Brussels in January, we created an updated aggregated map of mammalian livestock density, an important predictor of zoonotic disease risk. Livestock often act as "bridge hosts" allowing spillover of pathogens from wildlife to people, and here we show the total combined livestock population density of buffaloes, cattle, goats, pigs, and sheep. These densities are calculated from an FAO model that combines animal census data with predictors of livestock density including several vegetation, climate, topography, and demography variables. We present mammalian livestock density on a log-scale for easier visualization and clipped this map for each of the 28 PREDICT countries.

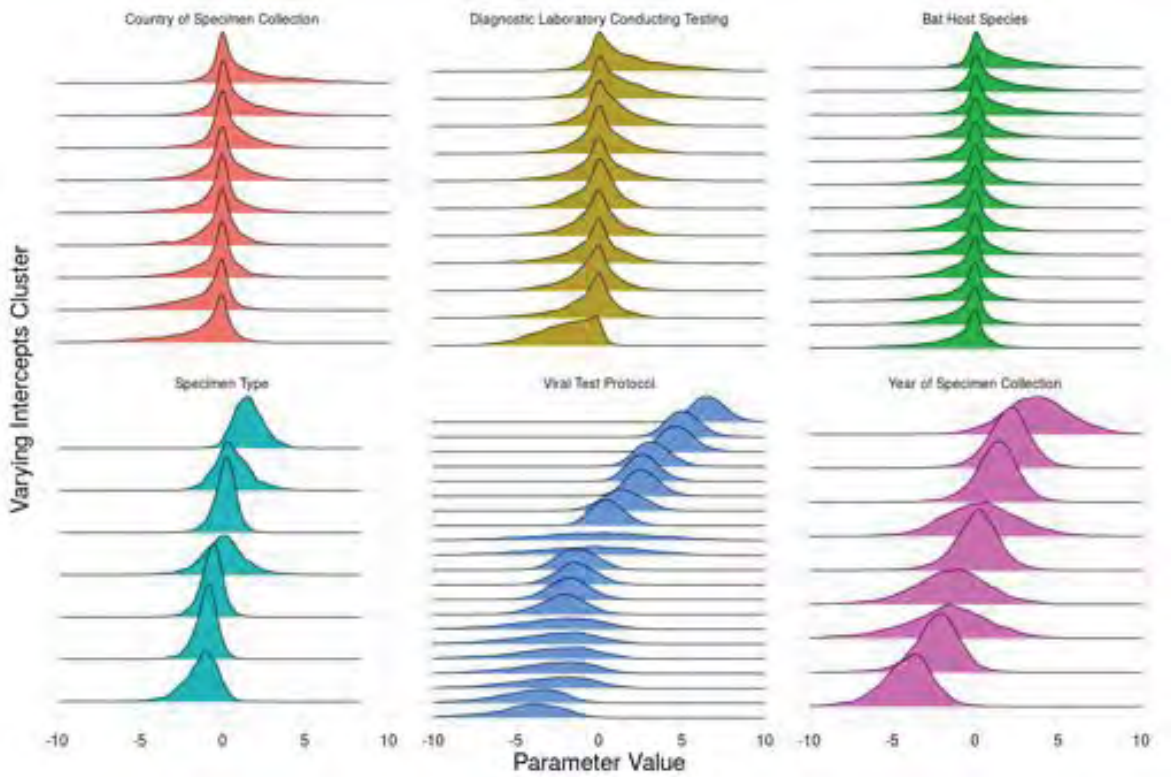
81 Global

Urban, pasture, crop, land-use with tree cover



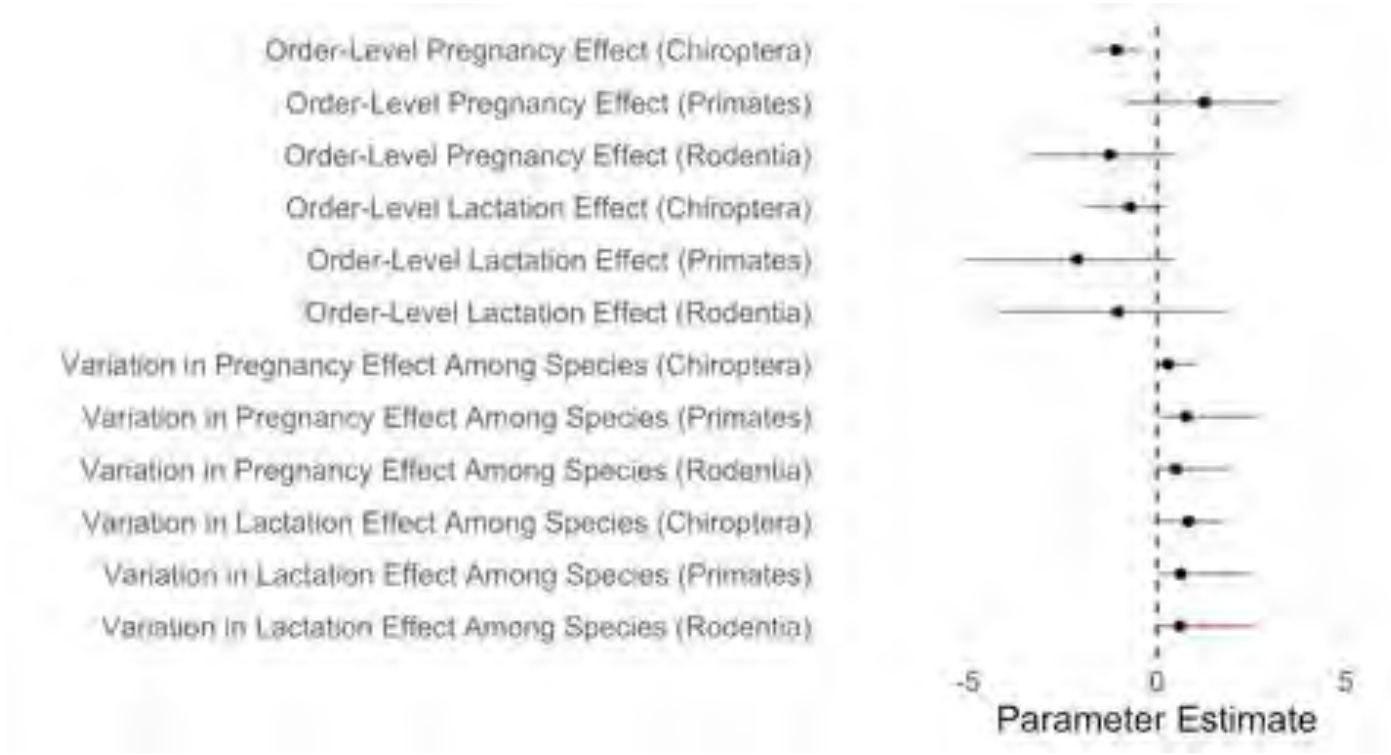
81. Global map of land use. For the PREDICT All-country meeting in Brussels in January, we mapped global changes in land use and urban area, both important factors in predicting zoonotic spillover risk. We assigned human land use categories as above for both 1970 and 2005 to show areas with the greatest change in urban, pasture, and cropland areas during that period.

82 Global Seasonality of viral shedding in bats



82. Refined seasonal model of viral shedding in bats. We refined a model to test for seasonal patterns in wildlife viral shedding (here shown for PREDICT bat data) while accounting for abiotic and biotic factors (e.g. age, gender, reproductive status) and controlling for methodological and technical variation within the data. These models will help us better understand viral dynamics in bats, which are particularly important for zoonotic disease transmission. They also demonstrate that large datasets such as PREDICT's are invaluable for scientific research.

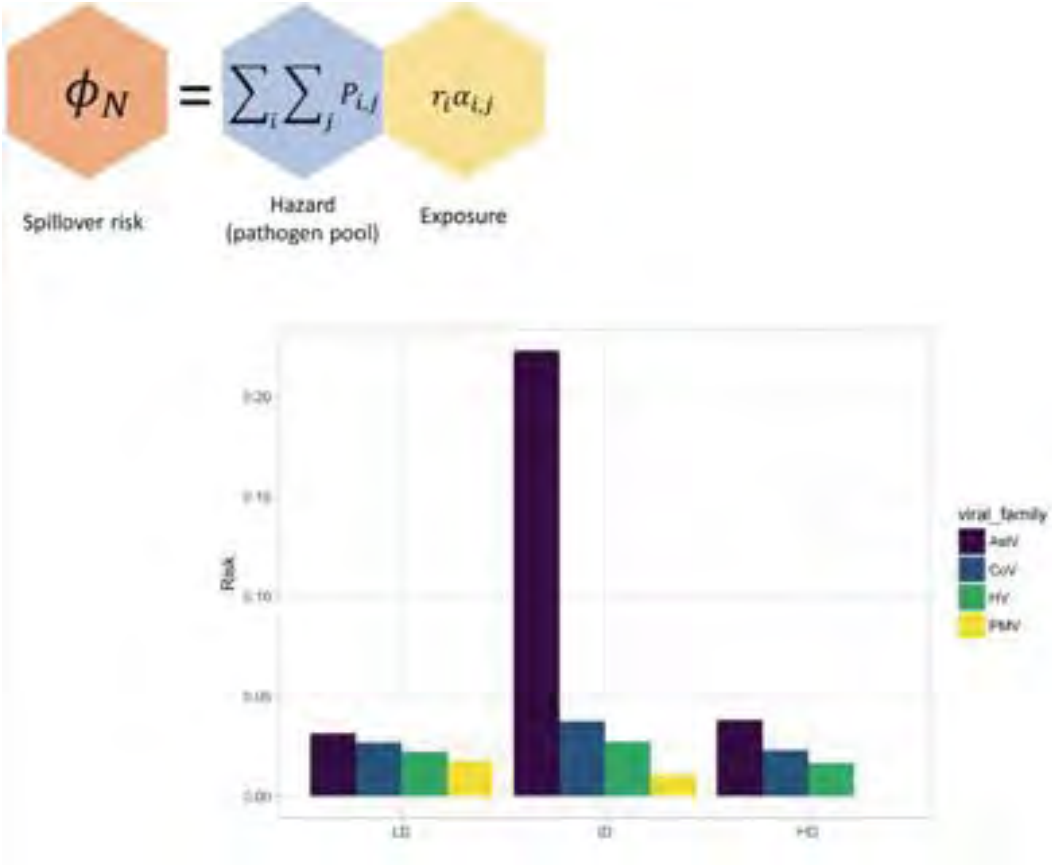
83 Global Effects of reproductive status on viral shedding



83. Modeling the effect of reproduction on viral detection across three mammalian orders.
Researchers have proposed that seasonal pulses in viral shedding are driven by patterns of reproduction in bats and other mammals, however this has not been tested across a multi-species dataset. We used a hierarchical Bayesian model of reproductive effects to test for increased viral shedding during pregnancy in order to understand potential spillover into humans. The dot chart shows order-level pregnancy and lactation effect from a model of viral detection in adult female mammals. Parameter medians (black dots) and 95% highest posterior density intervals are shown. Intervals are colored according to the mammalian order to which they apply: bats are shown in blue, primates in green, and rodents in red.

84 Deep Forest – Brazil, Uganda, Malaysia

Spillover along land use gradients



84. Spillover Risk - modeled across disturbance gradients (low disturbance, intermediate disturbance, and high disturbance) for 4 viral families. In order to understand the risk of disease spillover from wildlife due to land use change, the Deep Forest Project used human/animal contact rates, type of human/animal contact data, as well as viral and host diversity and abundance data to derive a probability of spillover event in Uganda, Brazil, and Malaysia. Further analyses are underway using this dataset.

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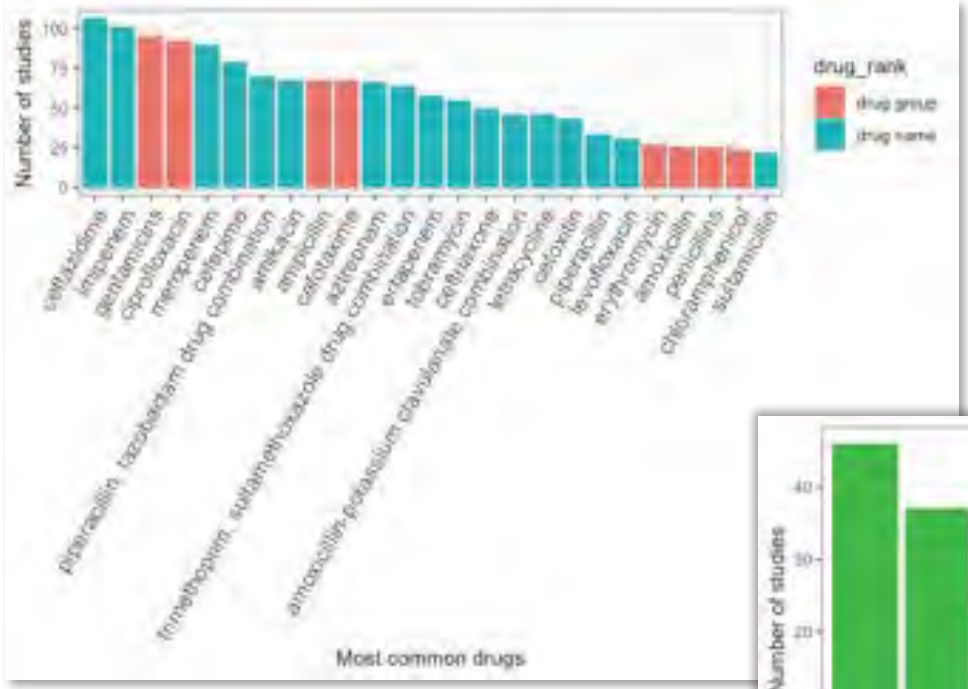
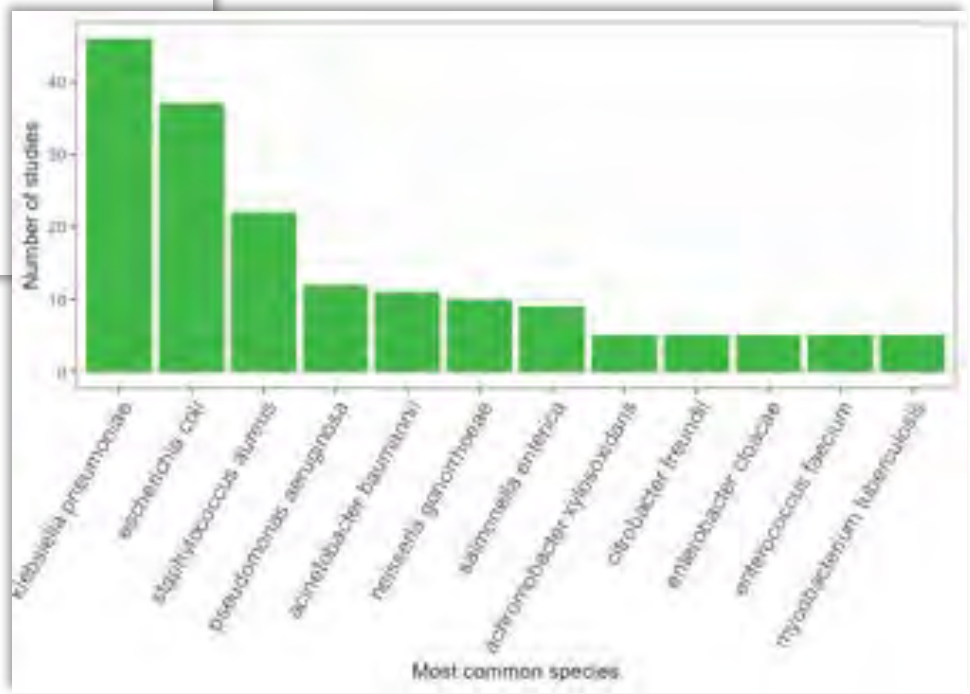
Emerging Threats Program 2 (EPT-2)

85 Global Distribution of Antimicrobial Resistance Emergence

85. Understanding the distribution of antimicrobial resistance events. PREDICT completed three rounds of article screening and two rounds of data extraction from a pool of over 24,000 articles to create a database of emerging antimicrobial resistance events in people. The database gives us a comprehensive view into the distribution of species, drugs, and places where AMR emerges, and provides the underlying data for a spatial 'hotspots' model of antimicrobial resistance emergence in humans, which will be the first of its kind.

86-87 Global Distribution of Antimicrobial Resistance Emergence





86-87. Understanding the distribution of antimicrobial resistance events. Number of studies by drug and most common microbial species in which new AMR combinations have been discovered in people.

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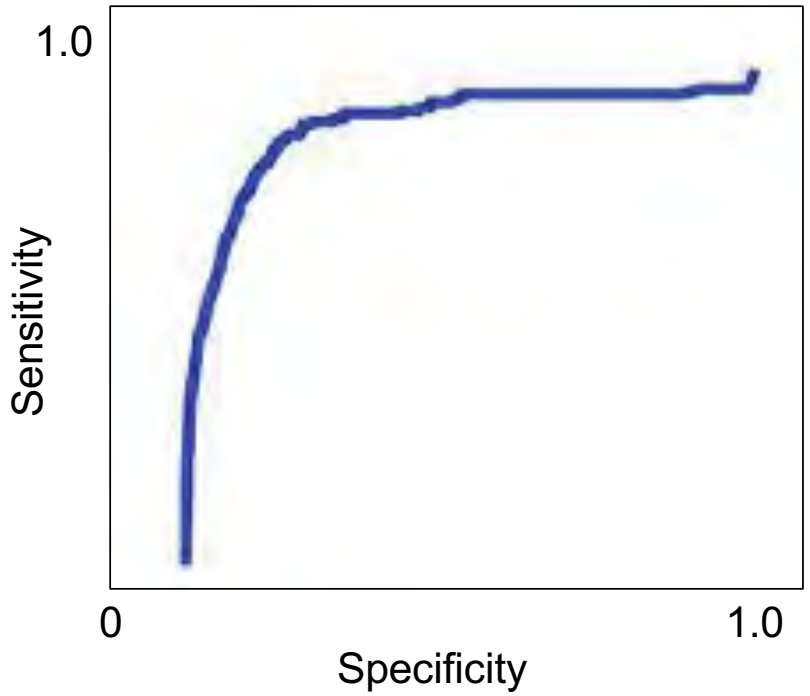
Distribution of Antimicrobial Resistance Emergence



88. Neural network model to detect antimicrobial resistance events. Using our database of abstracts to identify emerging cases of antimicrobial resistance, we developed and trained a neural-network model to automatically read scientific text to identify such cases. The model performed with 85% balanced accuracy, and could be tuned to detect 95% of cases while reducing hand-screening effort by 65%. This will allow us to update our database of AMR events in future years with much greater efficiency.

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